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FINAL REPORT OF THE SPECIAL COMMISSION TO INVESTIGATE THE WATER SUPPLY OF THE CITY OF PHILADELPHIA.

Philadelphia, April 5, 1883.

To the Select and Common Councils of the City of Philadelphia.

GENTLEMEN :—The undersigned have the honor to submit a final report upon the subjects referred to them, concerning the present and future supply of water for the City.

In the preliminary report made October 14, 1882, which your Board considered imperatively required in order that the City might avoid a short supply of water, certain recommendations were made for pumping machinery and mains, and for the construction and completion of reservoirs of distribution.

They have carefully revised the recommendations then made, and after a prolonged study of the subject, find no reason to change them in any essential particular.

In view, however, of the small amount immediately available for extensions, they recommend certain modifications in the application of the funds.

The resources understood to be available, and at the command of the Water Department, are as follows :

1. Appropriation of December 30, 1882,
   For the extension of Works..... $65,000 00

2. Appropriation of March 24, 1883, For the extension of Works	250,000 00
3. Appropriation of March 30, 1883, For the extension of Works	210,000 00
Total	$525,000 00

Which sum is now at the service of the Water Department.

The conclusions of the Board as to the most advantageous application of this sum are set forth in the following schedule:

SCHUYLKILL WORKS.

For engine and boiler house	$50,000 00
" two 15 million gallon engines	96,000 00
" two ranges of boilers and connections	65,000 00
" two 36-inch forcing mains, 2,500 L. feet at $15	37,500 00
" completing the laying of the 48-inch main to Corinthian Basin, 1,000 feet at $5	5,000 00
Cross connection from Corinthian Basin to Schuylkill and Fairmount Basin, 36-inch pipe	7,000 00
Tracks, coal-bins, etc	3,000 00
Total	$263,500 00

ROXBOROUGH.

For one 7½ million gallon engine	$47,000 00
" forcing mains, etc	3,000 00
" two boilers and steam pipe connections	7,000 00
" stack	2,000 00
" new Inlet, etc., screens and dredging	3,000 00
Total	$62,000 00

GERMANTOWN MAIN.

For 16-inch main, from Mount Airy reservoir on Allen's lane, to McCallum,		
McCallum to Carpenter, Carpenter, down Green to Tulpehocken	11,000 feet	
For 12-inch main on Green street, from Tulpehocken to Manheim street	6,500 feet	
	17,500 feet	
Total		$70,000 00

FRANKFORD.

For one 10 million engine	$47,000 00
" foundations	2,500 00
" steam connections	500 00
Total	$50,000 00

SURVEYS.

For Determining Sources of Future Supply.

For 2 parties per month (1 party per month at $1,000)	$ 2,000 00
" 6 months field work	12,000 00
" Analyses	1,000 00
" Office work	7,000 00
Total	$22,000 00

RECAPITULATION.

Amount available		$525,000 00
For Schuylkill Works	$263,500	
Germantown Mains	70,000	
Roxborough	62,000	
Frankford	50,000	
Surveying	22,000	467,500 00
Leaving a balance of		$57,500 00

Of which thirty-nine thousand five hundred (37, 500) dollars should be transferred to Item 15 of the annual appropriations for "buildings, grounds and reservoirs," and the remainder, twenty thousand (20,000) dollars, be allotted to the general contingencies of the Department.

The Board would modify the recommendations previously made in regard to the character of the machinery to be obtained, to suit the altered circumstances of the case. They advise for the Schuylkill and Roxborough Works, horizontal compound duplex engines, in general character similar to the Worthington engines at those works; and for Frankford Works, a compound rotating engine, of a form in some respects modified from that already in use.

The importance of the appropriation for the Germantown main is due to the imperfect supply in Germantown, the lower part of which

is almost without water, and its population depending on one small main. At the same time the water supply as far south as Allegheny avenue will be greatly improved.

The appropriation for "buildings, grounds, and reservoirs," is necessary on account of the small sum allotted to this item in the appropriation bill for the current year, wherein only eighteen thousand five hundred (18,500) dollars is made to cover items specifically named, amounting to fifty-four thousand two hundred and twenty (54,220) dollars, and further by the dangerous condition of some of the reservoirs demanding immediate attention.

At Wentz Farm, the slip of the bank and other defects have reduced the present capacity to less than half of the total contents, as only twelve feet of water can be carried in the lower area, as against twenty-two feet, which could be maintained were the basin in good order. At other reservoirs, also, repairs are at once required to prevent rapid deterioration.

The item of contingencies is important to provide against variations in cost from the estimates, for additional works which cannot now be estimated for, and to enable the Department to deal promptly and efficiently in the event of accident. Your Board regard as indispensable to the satisfactory working of the Department, that a contingent fund should annually be at its disposal.

RESERVOIRS.

In the foregoing schedule no provision is made for the reservoirs mentioned in the preliminary report. It was there stated, as to the completion of East Park, the acquisition of land for and the construction of Cambria, and the acquisition of land for and the extension of Mt. Airy, that "all of them are needed now, and will ultimately form proper centres of distribution, whatever may be the permanent source of supply for the city."

This remark is based upon the fact that the vast extent of territory to be supplied with water in the city, and the diversified character and altitude of its surfaces, point out certain locations as peculiarly fitted for points of distribution independently of the source of supply. It is not probable that better points could be selected now if the whole subject were an open one. The city has already expended large sums at East Park, and a storage for its levels of distribution of from four-

teen to sixteen days' supply can be had by completing it, at far less cost than in any other way. The location at Cambria and Thirtieth streets is as yet unimproved, and unless speedily acquired may be reached by building enterprises which will render it more difficult and expensive to obtain at a future time. There seems to be no better site for a reservoir to command this district, which already contains two hundred and thirty thousand persons, is now without any subsiding reservoir, and is growing more rapidly than any other part of the city. Adjacent to Mt. Airy Reservoir unimproved land can be had of suitable character and elevation at less cost than in the future. Its necessity for that section of the city is apparent when the small and totally inadequate dimensions of the present reservoir are considered.

Your Board would therefore again most urgently press upon your consideration the importance of immediately taking steps to acquire the needed land at the two points named, even if, as they are advised, no money is, at the moment, available for proceeding with the work of construction.

FUTURE SUPPLY.

Upon this most important branch of the subject your Board have bestowed much attention. But, owing to considerations hereinafter referred to, they find it impracticable at the present time to reach definite conclusions, or to submit any recommendations other than those embodied in this report.

In the preliminary report the following remarks were made:

"Meanwhile your attention is respectfully called to the fact that complete surveys must be made, and reliable data obtained, of the localities from and through which a pure water supply can be drawn, in order to form a correct judgment as to their availability. As it is essential that this information be obtained, an appropriation for such surveys of not less than fifteen thousand (15,000) dollars is suggested."

No steps having been taken in this direction by your Honorable bodies, it becomes necessary to again invite your attention to the subject, and your Board have included in their estimates for present expenditures, the sum of twenty thousand (20,000) dollars, which will enable the Department to place in the field, at once, surveying parties, and to work up the results of their labors. Under the most favorable conditions, the greater part of a year will be consumed in procuring the information, without which no intelligent judgment can be formed.

Indeed, in other cities large sums are annually expended for surveys to secure fresh information respecting the possible ssurces of water supply.

Recommendations heretofore presented for the supply of Philadelphia from distant points have, in the opinion of the Board, been based upon insufficient definite knowledge, and more recent investigations have shown, that in estimating the available rainfall and the effect upon the purity of the water of impounding it for long periods, views formerly entertained require considerable modification.

There are two main sources of supply, the Schuylkill and the Delaware, with their respective tributaries. At certain points each of these rivers furnishes an adequate amount of reasonably pure water.

At the points where the water for the city is now drawn, its impurity is constantly increasing, and is probably approaching the limit of wholesomeness.

The first inquiry, then, is clearly whether this impurity can be removed, or reduced to a safe point. If it can be so reduced, the present sources of contamination removed and guarded against for the future, and sufficient quantities be had, it is unnecessary to look to more distant sources. If this cannot be accomplished it will be needful to draw from one or the other of these rivers at points higher up.

To answer this inquiry, and to form a judgment of the cost either of purifying the present supply, or obtaining a new one, careful detailed analyses must be made of the water obtained from different points in order to trace the causes of impurity, as well as careful topographical and geological surveys. Gaugings of the streams, and of the rainfalls over the areas draining into the Perkiomen, Skippack, Wissahickon, etc., are required, as well as the upper affluents of the Delaware, if such should be found necessary. The surveys should be especially directed to ascertaining where, to what extent, and at what cost, impounding reservoirs can be constructed, and the several available routes for conduits carefully investigated, with a view to determine their cost.

At present the larger portion of the city's supply is drawn from the Schuylkill. It is evident that, so far as quantity is concerned, an abundant supply can be obtained for a long time to come, for its minimum flow is not less than two hundred million gallons daily, and this might be largely increased by additional dams, as was suggested

by the Park Commission sixteen years ago, and by the Board of Experts in 1875.

Formerly, the character of the Schuylkill water was of the first rank among the sources of supply for cities. If this condition could be restored, nothing better can be expected.

The first duty of the city is to remove whatever sources of contamination are imported within its own limits. The city's ownership of so much of the banks of the river as are contained in Fairmount Park is of the greatest importance in this respect, but the efforts of the Park Commission to preserve the purity of the water have been rendered almost nugatory by the constantly increasing drainage into the river from the east bank, caused by the growth of large manufacturing industries, and their attendant populations.

Your Board believe that analyses will show that the deterioration in the quality of the Schuylkill water, justly complained of, is largely due to this cause, and that the completion of the sewer from Flat Rock to below Fairmount will tend to restore its wholesomeness by removing a most serious source of pollution. The construction of this sewer has for many years been urged upon the city authorities, first, by the Park Commission, and subsequently, by others who have considered the subject, and it is a matter for congratulation that the work is at last to be undertaken.

Supposing, however, that when this sewer is in use, and when the city has exhausted all other means of preventing contamination within its boundaries, is it possible to control the pollution of the stream at higher points?

This introduces the question, whether by suitable State legislation, riparian owners, whether individuals or communities, can be compelled to observe toward the City of Philadelphia the common obligation incident to similar rights as between individuals. The principle is well established which preserves to every person the use of running streams only so far as he does not impair their use and purity for others.

It is the opinion of your Board that the determination of the question of future supply should be entrusted to a Commission to be hereafter constituted, before whom should be laid the fullest information attained or attainable, together with such reports, plans, and projects, as may be submitted by the Water Department after the necessary data shall have been gathered.

REDUCTION OF WASTE.

Next to the importance of obtaining a proper supply of water comes the question of its economical use. Experience in other places has proved that the loss from leakage of service pipes and stop cocks, and from allowing waste of water in houses, factories, etc., is enormous, and effective means have been devised for discovering this loss.

Your Board consider it essential to an efficient conduct of the department that the Chief should be empowered to use all known means for finding and correcting this evil.

Another source of waste is the absence of proper methods of determining and valuing the use of water in factories and large public buildings. For these your Board consider that meters should be used at the discretion of the Department. It is impossible even to approximate to the amount of water used, on the basis of a given size of ferrule, because the quantities passing vary in different localities, according to the pressure, and because the use in some localities is more constant than in others. The only equitable mode of assessing in such cases is by the quantity actually consumed. This at the same time should check wastefulness. In most of the large cities the use of meters for large consumers has been found of great value. On the other hand, it is not desirable to affix meters to houses.

The first cost of these meters would have to be borne by the Department, but they might be made to earn a large interest on the investment, and would undoubtedly result in so considerable an increase of revenue in certain cases as to warrant a reduction in others, and the furnishing of water to houses at a cheaper rate than at present. At the same time it would be found that the consumption per capita would decrease, and with it, proportionally, the expense of the Department.

SUMMARY OF RECOMMENDATIONS.

1st. The application of the appropriation as specified for immediate needs.

2d. The acquisition of land for reservoirs at Cambria street and Mt. Airy.

3d. The organization of a surveying staff, with duties as indicated.

4th. The consideration of general legislation for protection of streams from pollution.

5th. Adoption of measures for the prevention of waste.

CONCLUSION.

In conclusion, the undersigned deem it proper to state that owing to the prolonged absence of their colleague, Mr. Chesbrough, caused by his illness, the responsibility thrown upon them has been greatly increased, and they deeply regret that they, as well as their fellow citizens, have been deprived of his valuable services during the latter portion of their labors.

Respectfully submitted,

J. VAUGHAN MERRICK,
FRED. GRAFF,
WILLIAM LUDLOW,
Chief Engineer Water Department.

TECHNICAL TRAINING.

By THOMAS M. DROWN.

[An address delivered before the Alumni Association of Lehigh University, June 20, 1883.]

The part which the natural sciences of physics and chemistry play in our every-day life comprises about all that makes life practically worth living. A moment's reflection will convince one that to the physicist or engineer we owe all our methods of rapid communication and transportation, as well as the utilization and adaptation of power; and to the chemist we owe our supplies of metals and other necessaries of modern life. Technical schools have for their object the teaching of these sciences, with the direct purpose of their application to the well-being, the pleasure, the comfort, and the convenience of mankind. We will devote this hour to the inquiry how this object can be best attained.

Empiricism is the foundation of all art and manufacture. Nearly all the early discoveries in the arts were the result of accident or haphazard experiment. Useful results, which could be regularly reproduced, gave value to discovery and dignity to the discoverer.

It would be interesting—to take an illustrative instance—if we knew the circumstances connected with the discovery of metallic iron. We can well imagine that a fire, large and intense enough to reduce iron from its ore, must often have been made in accidental contact with

surface ore, and that the presence of the metal in the ashes must have attracted attention. This observation once made, there would follow a series of experiments to determine the conditions under which the metal was produced, and the substances necessary for its production. It would not long escape intelligent observation that a certain red or brown earth, or may be a black rock, was the substance which yielded the metal, and that fire was the necessary condition of its formation. Then would, doubtless, follow many fruitless experiments with rocks and earths of similar appearance, until finally, the experimenters would learn to distinguish by the appearance, weight, color, etc., the deposits which contained iron from those which did not. But the iron thus accidentally produced—a mixture of metal, cinder, and ashes—was of no value until further experiment revealed the fact that the metal could, when hot, be united, by hammering, into one mass, with the separation of cinder and other extraneous matter. The discovery of this property of iron, as notable as that of its production from the ore, prompted still further experiment. The irregularity of the product would suggest the more perfect control of the fire, and small furnaces would be built with manifest advantage. Again, it would be found that ores from different localities behaved differently in the furnace or gave iron of different properties; and the best and most easily worked ores would be carried to distant furnaces, or the iron smelters would move to the vicinity of the best ores and build their furnaces there. In the course of time it would be noted that the iron was not uniform in hardness, and an accident would be sure to reveal the fact that sometimes the metal, when suddenly cooled in water, would become intensely hard. This new line of investigation would result in the more or less regular and controlled production of steel.

As the result of all this experiment certain favored regions would become celebrated for the manufacture of superior utensils and weapons of iron and steel, and certain men, more than usually intelligent or experienced, would become famous for their skill.

This was the school in which were trained the famous masters, who by work at the forge and anvil made themselves names which history passes down by the side of princes.

In museums of mediæval art we see specimens of smith's work which excite our wonder and admiration. These were made by the masters at the forge with intelligent, patient, and often loving labor. We see the sword which was carried and used by some warrior of old

still fit for new conquests; we see the strong box, with cuning lock, in which some castle-robber kept his treasure; and we see the delicately-wrought screen of leaves and flowers, hammered from the soft and willing iron, which found its appropriate place in a cathedral.

In those days there were no technical schools, and, it may be asked whether, in such arts, we derive any practical benefit from school teaching. Is not rather the pupil's place at the master's side taking lessons, hammer in hand, while the master directs the blows? It may be safely answered that no system of class teaching, which modern experience or necessity has devised, can impart that subtle element of genius with which great minds, full of enthusiasm, inspire their loving pupils. Class teaching is a necessity in our day of general education, and the best that the teacher can do, in many cases, is to ignore individual differences, and to bring his pupils all to the same level in knowledge. It is a machine-like process that aims at a good, uniform product. The enthusiasm begot of the intimate relations of teacher and pupil must be subordinated to the general good of a larger number. The loss of this personal enthusiasm, while much to be deplored, is not without its compensations. The fact that say a hundred young men are taught where but one was taught before, not only multiplies the actual number of educated men but renders the evolution of great minds more probable. In the arts which are less capable of formulation the master system still survives. In painting and music there is a first, or mechanical, stage which can be learned from competent teachers in classes; but there is a stage beyond this, where the inspired master speaks a language which only the worthy pupil understands. Genius cannot be taught, but it may fall like the prophet's mantle on him whose gaze can follow his master into the celestial fire and see the forms of beauty and strength.

There is also in all the *practical* arts a region beyond formulas. It is in this region, shut out as by a cloud from the sight of the multitude, that the prophets live, spending their time in translating eternal truths into the language of men.

But, further, it is impossible to conceive of a school in the day of purely empirical knowledge. Art is appropriately taught in the shop; science, or classified knowledge, belongs in the school. It is nowadays rather the fashion to admire the works of the past, and to mourn over the degeneracy of modern art. It is true that the workmanship of old was often more thorough and complete than we find it in our day,

not because the art was better understood, but because more time was taken to it. Time has increased in value, and it does not now pay to linger over the manufacture of a cabinet or table.

The mistake is often made of comparing the industrial arts of to-day with the fine arts of centuries past. Chairs, and tables, and carpets, and clocks belong to the necessary furniture of every-day life. Shall we mourn over the fact that they are now made simply and cheaply because we find that some of our ancestors lavished ornaments on their furniture, and studded their clocks with jewels? Does any one suppose the mass of the people of that day lived with these artistic surroundings? Fine art is not limited to paintings and sculpture, and in our day, we too, when time and wealth permit, refine our household goods into works of beauty.

There is a good deal of nonsense talked about "lost arts." There have been very few arts lost which were worth keeping. Disused arts are abundant enough, and may be revived if the demand arises. It is safe to say that the modern workman could imitate and improve upon any of the works of mediæval art in metal or wood if he thought it worth while. Do we not hear rumors of modern enterprise which can supply genuine antiquities fresh from the factory?

The mediæval workman, should he return to the scene of his earthly labor, would find himself unable to compete with the modern mechanic in his own art. His hand might retain its old cunning, and his soul be full of high purpose, but his forge and work-bench could not compete with the machine shop and saw mill.

The fine arts may rise and fall and rise again, but in the industrial arts there is steady progress.

How then have schools arisen? In the course of time as facts accumulated, and when it was found by the pupils who journeyed from one master to another, that the explanations of well-known facts were nearly as numerous as the masters, the necessity of classification arose to develop some order out of the tangle of facts. This is the period when schools appear, when men drop their tools to think over their work, and compare it with the work of others. The school is at the start an annex of the shop, having for its object the systematic arrangement of the facts which the shop supplies. But the school cannot long remain the patient handmaid of the shop. Facts developed by accident or experiment come too slowly to supply the mental machinery which has been put in motion, and the imagination supplies the facts

which the mind demands—prophecies of discovery which experiment confirms or refutes. Now begins the era of intelligent investigation, and we have more than an industrial school which deals with the best practice, we have a school of science which seeks the causes of things. All technical schools go through this course of development—in engineering, chemistry, metallurgy, architecture, and even medicine, for it too is largely an experimental science.

The school, born of the shop, in time attempts to control its operations, and the inevitable conflict, so called, of theory and practice arises.

When sanitary science began to direct attention to the necessity of a better drainage system for houses, the workman in solder and pipes defiantly placed over his door the sign "Practical Plumber." Scientific agriculturists likewise developed the "practical farmer." There is scarcely a trade which has not taken alarm at the tendency of modern investigation, and many a craftsman fortifies himself against anticipated attacks in announcing himself; for instance, as a "practical hatter," a "practical cobbler," or a "practical bell-hanger."

Nor is it only in the trades that this reactionary tendency is noticed. Even in the professions which deal mainly with matters of mind or emotion we meet the suggestion of—the "practical lawyer," the "practical physician," the "practical politician," or even the "practical theologian." In matters of fine art too, it is often felt (but less often confessed) that the tendency is to expression beyond the comprehension of the layman, who would gladly welcome the revival of what he might call the "practical painter," or the "practial musician."

The phrase "conflict of theory and practice" is often used without definite meaning. Muscular labor is always conservative, and the conservatism is in direct proportion to the physical strength involved. He who works with heavy tools is more set in his ways than he who works with lighter ones. Manual dexterity is the transition from muscle to mind. Mental labor, on the other hand, is always radical, and is apt to forget the things behind in its striving for things ahead. The "conflict" is the inertia of labor opposing the restless advance of mind; it is in the nature of a check or brake which practice puts on the train of thought. Viewed in this light there can be no victory on either side, for both work together for the best result. Life would be the monotonous affair that Solomon found it "if the thing that hath been is that which shall be, and that which is done is that which shall

be done;" but worse than this monotony would be the confusion, the chaos, that would result if theory proclaimed itself independent of practice. Human society has decided the former life to be merely dull, but for the latter it provides insane hospitals. The conservatism of labor is often mentioned with unjust reproach; we demand of labor, accuracy and uniformity, just as we do of machines, and we constantly endeavor to eliminate irregularities of product by division of labor, or by the construction of machines which do not get weary, do not go on sprees, or strikes. If, after this narrow training, we find that the human machine opposes the introduction of new ideas or processes, should we be surprised? We might as well complain that a horse-shoe machine would not adapt itself to make pins!

It is not unfrequently noticed that men who pride themselves on being "practical," are the most inveterate theorists; and equally droll is the quiet confidence that the schoolman often has in his ability to work in the shop or mill if he wanted to. It needs the personal contact of these two classes of men to develop mutual confidence and respect, with the elimination of ignorance. Happy is the man who combines in himself both the knowledge to think and to work.

We are very fortunate in this country in having a society in which the schoolman and craftsman, the engineer and the iron worker, the chemist and the furnace man, meet on common ground, without fear or jealousy, to learn from one another. No society in our day has made more real progress and done more good work than the American Institute of Mining Engineers. Its *Transactions* contain the record, side by side, of the best practice and the highest scholarship. This is the *fellowship* of theory and practice.

Technical schools are not indigenous in this country, they have been transplanted from Europe, and were originally formed on German models. The rapid development of our mines of the precious metals in the West, found us without the necessary technical skill to work them advantageously, and we were particularly deficient, two or three generations ago, in the knowledge necessary to work these ores profitably. German metallurgists came in large numbers to this country, and our young men were sent to German mining schools to fit themselves to take charge of mines and smelting works.

Many of us can well recall the young American returned to his native shore after a sojourn of two or three years abroad. He brought back with him an elaborate case of blow-pipe instruments, a collection

of minerals and hammers, a well-assorted library, particularly rich in the German classics, an intimate knowledge of foreign social customs, a vocabulary liberally enriched in foreign technical terms, and a look and an air that seemed to say, "I am ready to show you how it is done." They had no difficulty in securing positions to put their knowledge to practical use, and while a few of them were successful, it must be confessed that many of these young men made lamentable failures at the start, causing loss to mine and mill owners, and bringing discredit on systematic instruction. We must also admit that the early graduates of our American mining schools were also often unsuccessful at first. There was evidently something wrong either in the works or in the school; and as a consequence, the school teaching of practical science sustained a serious check. The schools thought the works were jealous and put obstacles in the young men's way, and the shops thought the teaching of the schools impracticable, and unfitted the men for work. The trouble was simply that the young men had studied one side of the subject and attempted to practice the other. It was the case of an imperfect science attempting to instruct a well developed art. The case was complicated by the fact that the schools gave diplomas, asserting the graduates to be "civil engineers," "mining engineers," etc., and no wonder they thought the faculty knew best on this point.

Very often the trouble arose from the attempt to introduce foreign metallurgical methods into American practice, ignoring the fact that mining and smelting are primarily economic problems, and that the successful treatment of ores in one locality may be a failure in another. It is not in the least soothing to the capitalist, who discovers that his metallurgist uses more money to get the gold from the ore than it is worth, to be told that the process was scientifically correct and had been successfully used elsewhere.

Patience on one side and perseverance on the other brought about, at length, a better understanding, and the practical man recognized that the graduates of the technical schools were the best raw material for making promptly managers and superintendents. The school learning gave him an advantage at every stage of his work over the ordinary workman. This recognition reacted favorably on the schools, and the young men no longer thought their first duty was to instruct, but to apply their school knowledge. There is now no longer any distrust of the schools on the part of the works, in fact we may say that the schools have conquered the works, for the practical managers are now

very generally the graduates of technical schools, and are very glad to get young men with technical training. They know just how to treat them and what kind of work to put them at. More than this: these managers begin to discriminate among the schools, finding some young men better trained than others, and there has thus arisen a beneficial rivalry among the schools to give young men the preparation best calculated to secure them places for work. Competition in schools is as healthy as competition in trade, and it is worth while to discuss the question what is the best course to pursue in teaching science as applied to the arts. Let us first try to define a technical school, or rather to determine its relations to other schools. We will begin negatively, and say.

1st. It is not a school of general culture. We must not attempt to crowd too many studies into a technical course. The student should, as far as possible, have in mind a clear outline of his course from the beginning. And yet no greater mistake was ever made than that which asserts that the engineer or chemist does not need to be liberally educated. In the year 1876 there was a discussion in Philadelphia, under the auspices of the American Society of Civil Engineers and the American Institute of Mining Engineers on the subject of Technical Education. It was called by the lamented Alex. L. Holley to consider mainly the question whether shop practice should precede, follow, or coincide with technical instruction. A considerable number of schoolmen, practical engineers, and metallurgists took part in the discussion, and nearly all of them insisted that the most important requirement of the engineer was culture. It is a narrow life that concerns itself solely with building bridges or making analyses. The best professional work is done by him whose life is spent in a gentle and cultured environment. It is deplorable to find a trained and competent engineer unable to write a report clearly and correctly. But what else can we expect when young men are sent to technical schools *instead* of to high schools and colleges? A professor in a Hungarian mining academy once said: "If there is any study in which you are particularly interested don't make your living by it; keep it for a hobby." This advice does not always hold good, but it contains the germ of a useful truth, that professional men should have interests of an elevated character outside of their daily work.

2d. It is not a scientific school, as this term is generally used; that

is, a school in which the culture consists largely in the study of the natural sciences.

3d. It is not a school of pure or abstract science.

4th. It is not an industrial school in which the practice of an art is taught.

Technical schools are broadly distinguished from schools of general culture or science, by reason of special duty for a definite end, and are distinguished from schools of abstract science by the element of hand-work which enters into them. From industrial schools they are distinguished by the element of experiment or investigation. Turning to the positive aspect of the subject we say,

1st. A technical school is primarily a place for the preparation of young men to earn their living in engineering, mining, chemistry, etc. Any system which overlooks this or makes it of secondary importance is faulty and unjust. Young men are sent to these schools with this end definitely in view. It is easy for any one to earn his living in mining or engineering with muscle and pick, but schools are established to fit him to make a better living with brain and pencil. It is the lighter equipment which does the most work and earns the most wages. A technical school can then be fairly judged by its results, namely, the character of its graduates. Are they the better or worse fitted for earning their living with their school learning than they would have been without? This is a fair test question. And yet most of the teaching in the schools is of a preliminary nature. Young graduates must begin at the bottom in practice, but in this position they are still generally able to earn something. Analytical chemistry is the only branch usually taught in the schools which is complete in itself and not necessarily preliminary to other work. The analytical chemist is, therefore, on graduation fitted to take an independent, responsible position. His work, after he leaves the school, does not differ in kind from that in the school. The same may be said in some degree of the department of physical testing, though this is less developed in the schools than analytical chemistry.

2d. A technical school is a device to save time. Man has always chafed under his limitations, and failing to discover an elixir which should indefinitely prolong youthful and vigorous life, he has directed his energies to making his allotted span fuller and richer. Man's days are still three-score years and ten, but he now crowds as much into them as Methuselah did into his nine hundred sixty and nine. It is

generally considered good advice to youth that they emulate the career of noble, self-made men, who, beginning life poor, with no one to lend a helping hand, have struggled with fate and conquered, not merely acquiring wealth but knowledge. History is full of the names of such men, and the lesson they teach has only too often been interpreted to mean that success is conditioned on hardship, disappointment, and delay. But do these same self-made men thus read the lesson of their lives; do they advise young men to turn back and follow in their footsteps? Not so; rather do they say to young men, "I would not that you be spared thought, but I would save you from anxious thought; I would not that you be spared work, and even hardship, but I would save you from wearing uncertainty, and from that waste of precious time that my education has cost me; I would have you not go over the ground that I have gone over, but begin in youth where I leave off in age." Thus have acted, if they have not thus spoken, those great benefactors of our own valley—Asa Packer and Ario Pardee—in founding schools for technical education, that young men, without means, might not lose time in fitting themselves for useful work.

The will and the power to add a score of years to a useful life is benevolence almost divine.

3d. A technical school is a post-graduate school. In this respect it ranks with schools of law, theology and medicine. It is only in recent years that law and medical schools have taken a definite stand in regard to the proper preparation for these studies. Parents would choose between business, college, or a profession for their sons, and medical schools permitted men to matriculate without a question as to even a common school education. This condition of affairs is now fortunately passed—or is rapidly passing away—in the so-called learned professions, but it still exists to a great degree in technical schools. The reason is clear enough. These schools have grown out of the works and industrial schools, and their professional character is not yet fully recognized. Industrial schools train mechanics, technical schools train engineers. This distinction finds an apt parallel in training schools for nurses, and professional schools for physicians. We must not expect the public to discover and insist on this distinction; it must be made by the technical schools in setting their qualifications for admission.

4th. A technical school aims to teach the relation of abstract science to the practical arts. If we examine the catalogues of these schools

we find a long list of subjects—mining, mechanical, and civil engineering, metallurgy, chemistry, physics, geology, mineralogy, drawing, mathematics, languages, etc.,—and to the list might well be added sanitary and electrical engineering. All of the studies have a direct bearing on human welfare. But the great number of them, with the ever widening scope of each, renders the arrangement of a course of study very difficult, and we not unfrequently find in a course a most heterogeneous collection of studies whose relation is merely superficial or one of sequence. Take for instance the course of mining engineering as taught in many schools. To obtain the degree of "mining engineer," the student must have a certain knowledge of geology and topography to locate ore-deposits, he must be a mineralogist to determine the occurring minerals, a mining engineer (in its narrower sense), to take out the ore, a chemist to assay it, a mechanical engineer to build the necessary machinery for hoisting and ore-dressing, and a metallurgist to extract the metal from the ore and work it into useful forms for the mechanic and civil engineer. To all this is often added a course in bookkeeping and mining law. It must indeed be a well-rounded man who has taken this all in.

A course of this kind is a survival of the time when all that was known on all these subjects taken together would not inordinately tax a youthful intellect; but as these subjects expanded, each into a science in itself, instructors neglected to divide the course into several independent courses and went on cramming the student to a point of unsafe tension.

Perhaps no classification that we could make of the branches taught in technical schools would meet the demands of all students, on account of the interlacing of the branches. At first sight we think we have a natural sequence in the subjects just named, that is, geology, mining engineering, mechanical engineering, metallurgy and civil engineering, and that we could divide this course into two or more courses by drawing lines anywhere between these studies. But this would make very artificial divisions. Mining engineering is not very different from civil engineering; the mathematical basis is the same in both and much of the work is the same. In fact, many of our best mining engineers have been educated as civil engineers, and have afterwards transferred their field of operations from the surface of the earth to its interior. It is not a very long step from the engineering of construction to the engineering of destruction.

Again, both the mining and civil engineer should know a good deal of mechanical engineering, which deals with the mechanisms for the utilization of power. The metallurgist is primarily a chemist, but the more he knows of mechanism and construction the better able is he to carry on his work. And so we might go on to show that the more a man knew of all these related branches the better he could perform his special work—an argument which would simply go to prove the advantage of omniscience. Unfortunate as it is in many respects we must be reconciled to the necessity of becoming specialists, and to call in other specialists to help us. Perhaps the most we can hope for is to be an expert in one department and to know enough of the related departments to judge of the harmony and fitness of the combined work of many heads and hands.

In a general way we may divide technical studies into engineering and metallurgy, but a broader and better division would be into physics and chemistry; under the former subject being arranged those studies which have a mathematical basis, and under the latter metallurgy and other chemical branches.

At the risk of overthrowing both classifications it must be mentioned that a most useful combination course is one in metallurgy, which ignoring all engineering branches, deals with the chemical and physical properties of metals and alloys. This is the great virgin field in technology which promises a grand harvest of valuable results to him who works it patiently and intelligently. The civil engineer does well to complain that the ignorance of the metallurgist with regard to the properties of the metals used in construction hinders his progress and introduces great uncertainty into his work.

To the question what should be the method of teaching, I would say,

1st. Negatively—nothing should be taught in the schools which can be better taught in the field or shop. While this broad proposition must meet with general acceptance, there is yet a great diversity of opinion where the line should be drawn between shop and school, or just how much shop belongs in the school, or how much school belongs in the shop. It is not my purpose to enter into this discussion at present, but it will be admitted by all that,

2d. The school rather than the shop is the place for finer research and experiment.

3d. The subjects taught in the schools being largely experimental,

and consequently belonging to the growing and advancing sciences, it should be the object of the teacher not only to give the student the present condition of the science, but to identify him with its growth.

As to detailed methods of teaching, it is not well to enter too minutely, for this is a matter for the individual instructor, who will have, if he is in earnest, his own methods based on his own experience or his own theories. This personal element we cannot eliminate, if we would. And yet there may much good come from the discussion by teachers of their methods and results.

Teaching involves three processes—*instruction*, or the imparting of information; *education*, or the development of the mental faculties; and *training*, or the formation of habits of thought and work. Good teaching, whether in kindergarten, college, or professional school, is the happy combination of these three processes. In childhood, the element of instruction predominates; in colleges, education; and in professional schools, training; but no one of these elements can be absent in any kind of school without an imperfect result. In technical schools there is a good deal of general information which must be acquired, and a good deal that must be memorized, there is no escaping it. There is a certain amount of preliminary work which must be done, once for all, without which no sure progress can be made. There are no short cuts to knowledge at this stage. In education, the instructor's work assumes greater delicacy; it should be full of suggestiveness and guidance to develop the reasoning faculties and guard against their inaccurate or desultory action. Training, or the formation of habits, is a very different process, and one, the importance of which is not, I think, fully appreciated. The frequent repetition of any action not only enables one to do it easily but also to do it automatically. Muscular action is largely automatic. When one slips he throws out his arms to keep himself from falling; this is not instinct, it is habit. If he had to consider every time he lost his balance how he should restore the centre of gravity within the base, he would have many a fall which he now avoids. We admire the accuracy and precision with which a blacksmith wields a sledge, or the dexterity of hand of the accomplished musician which transmutes the printed page into melody, or the prompt and graceful evolutions of soldiers at the word of command:—all this muscular exertion is done with scarcely any expenditure of nerve force.

The mind, too, can be trained to think and act in defined channels

with great saving of power. Consider for a moment, how specially trained men look upon any object or incident. A jewel may be simply a thing of beauty to the ordinary observer, but to the mineralogist it is a crystal having a certain color, hardness, specific gravity, etc. So does a botanist classify a flower, or a geologist a fossil. In like manner in the recital of an incident, say a railroad accident; an engineer will at once think of the cause, a physician of the injured, a lawyer of the damages. These thoughts arise automatically, and are the results of training. The saving of vital energy which this training effects is one of the great economies of life.

The process of growing old consists in the ossification of thought and action into habit. It is obviously the duty of a teacher to have an oversight over the mental habits that his pupils are forming. A fact or a law mislearned can be corrected without much harm being done, but slovenly habits of thought, the substitution of guessing for proving, incomplete experimenting with the multiplication of factors of ignorance—these are practices which, when confirmed into habits, can with difficulty be eradicated.

Morally, habit is a very good practical substitute for purpose, and it may be said, in passing, that moral teachers too often overlook the good that could be accomplished in training in right thinking and acting. It is not an altogether utopian notion that one, for instance, could form the habit of telling the truth, which would serve him in good stead and save his moral nature from many an embarrassment.

If I mistake not, the principal work of a technical school should be the training of young men in accurate habits of thinking and working. Without this training the graduate is slow to adapt himself to new situations. The student who has been put through a routine course of study, abounding in the use of text-books and in the solving of many problems, may be fairly informed as to the condition of his profession and may have acquired good habits of study, and yet be unfit for practical work which involves principles which he has not learned. The proper training cannot be given in the class room, but must be obtained in laboratories.

And this is the thought to which I wish to give prominence: that the centre around which should cluster all the teaching of a technical school should be physical and chemical laboratories, and that the ruling idea of the school should be experiment and research. The time has

now fully come for technical schools to take this advanced position in the scientific training of engineers and metallurgists.

The development of the school out of the shop has been so gradual that it is somewhat difficult to realize that the differentiation is now complete, and that the methods which are adapted for industrial schools do not fit the professional school. There are those who regret the widening of the gap between head-work and hand-work, but this regret comes from a misunderstanding of the situation. Technical schools are not intended to teach a young man to puddle iron, to lay rails, or clean castings,—useful work, indeed, which he can readily learn before he enters the school or after he leaves it. We should not declare his education imperfect or worthless because he cannot handle a rabble or chisel.

A great difficulty in teaching a growing science is that what is taught to-day may be obsolete to-morrow. One who has spent four or five years in a technical school will realize this when he gets into actual practice. Ought there not, therefore, to be a system of teaching which shall recognize this growth and be adapted to it? To this it may be objected that the worst possible preparation for actual work would be to give the student the notion of the general instability of things, and that he must be on the look-out for the latest novelties in his profession. But we need not render unstable the attitude of a student by showing him that the ground on which he stands moves, and that he will be left behind if he does not move with it.

It has been said (to change the metaphor) that a teacher should be abreast of the current of thought in his profession. The figure is fortunately chosen in that it enables us to point out a grave mistake. He should not be abreast of the current, he should be in it, irresistibly borne on its surface and adding by his weight to its momentum. It is the introduction of the student into this current that should form the principal work of the teacher. The majority of students and workers never get into it. This may be the fault of the teacher, or it may be that the student is timid and prefers to keep up with the current by running along its borders. A few succeed in the attempt, but the majority give up the tiresome race and stand and see the stream go by. The figure illustrates the process of acquiring knowledge from books or practice alone—a process not without value to those whose imaginative and questioning faculties are undeveloped, and who prefer to take their facts at second-hand. But no teacher should be satisfied to let a

student take this stand until he is convinced that he has not the ability and aptitude for original work. The life of the collector is a narrower one than that of the discoverer, and the teacher's duty is to show the more excellent way.

What process of teaching will put the student into synchronous motion with the science that he is studying? Again, I reply, the training of experimental laboratories. This training cannot begin too soon, it cannot last too long. No special preparation is needed for it other than a little preliminary practice in the use of apparatus and methods. The student should live in the atmosphere of investigation. There should be no separation of beginners, advanced pupils and professors, but all should work together as far as possible. No teacher is primarily interested in teaching who does not like to have students about him when he is experimenting. By this association of workers there is a manifold advantage, for each one can follow in a general way the work of his neighbors and profit likewise by their experience.

The student should feel as soon he enters a technical school that it is a laboratory of research and that he is one of the workers. Much patient plodding is yet before him in studying text-books and showing he understands what he has learned by recitation; but his study is no longer drudgery, for he sees immediately its application. I often wonder at the patience of youth who devote years of their life to school-room work with quiet faith that their studies will sometime have practical use, and who cherish perhaps a furtive hope that they may live to discover a new and interesting fact. I wonder, too, at teachers who think that a student must not too soon get a notion of his own powers lest he should become unmanageable through over-confidence. What would we think of a system of studying botany which shut up the student for years within four walls where he could not see a green thing, and supplied him only with dry specimens and pictures of flowers and trees, for fear that a glimpse of nature's wealth of growing forms might lead him away from their systematic study? The comparison is scarcely overdrawn. In many schools chemical laboratory-work is regarded as a preliminary practice for useful work hereafter. A certain number of substances—simple salts, mixtures more or less complicated, rocks and minerals are given to the student to work on, and his only interest is to get the correct result, as a boy ciphers his sum towards the answer given in the book. Such work is depressing and of the nature of a task, and it is scarcely a matter of

surprise to find, in cases where there is an unsuspicious teacher, that the work is slighted and the results taken directly from a key which the students of one class thoughtfully pass down to their successors. The proposition to give to the beginner some interest in his work, in the nature of an original investigation, which would yield results having value in themselves, is one, I fear, which the ordinary student would receive with surprise, and one which many a teacher would consider a sure method of leading a student away from the sober studies he came to school to pursue. Those who thus reason don't understand the proposition, or they have never tried the experiment. It is not proposed that a student should neglect to acquaint himself with the fundamental principles of the science he is studying in his endeavor to get new facts. No more harmful suggestion could be made than this, that the object of one's studies is principally to discover something. There are plenty of people doing just this thing—shiftless, unprofitable workers, always on the verge of a great discovery which is to revolutionize things generally.

In the system proposed the development of this class of discoverers is impossible. No one knows the value of a fact like him who has secured one for himself—isolated it, weighed it, measured it; and no one knows and feels the harmony, and beauty, and power in a law like him who has collected many facts and seen them crystallize into transparent truth. No one is less likely to be led into error than he who has been trained to prove all things and to hold fast that which is true.

The notion has considerable prevalence that discoveries in physical science come in the nature of revelations, through specially inspired channels. I doubt if many students of engineering and chemistry look forward to a career of investigation and discovery, unless they should have a kind of "call" to the work. And yet if we go into any chemist's or physicist's laboratory we can hear of thousands of unsolved problems which are merely waiting for patient, thoughtful, trained workers.

It should be the chief object of the technical school to give this training. It belongs in the school and can be better given there than elsewhere. The probability that a student will ever have the opportunity to get this training after he leaves the school is very small. Practice he will get enough of, but the ability thoroughly to investigate statements and processes does not come with the daily practice of

an art. It is not merely the skilled hand and quick eye that is needed, it is the trained mind which not only gets at the truth but shakes off error.

This process is often spoken of, figuratively, as questioning nature, who always replies promptly and clearly and without hesitation or reserve. How is it then that so many of her answers appear enigmatical and confusing? Simply because the question is not properly put. To continue the figure—investigation may be called the art of putting questions; and this art very few people possess even though they may be endowed with a prying inquisitiveness. Nature is not a gossip, does not speak until spoken to, does not tell more than is asked of her. But it is a process, I insist, that can be taught, and it is much better that one should learn it properly than depend on the chance of picking it up. Things which are picked up are generally imperfect or rusty.

While the object of the method we are advocating for technical schools is not primarily the discovery of facts, but rather the training which this method of investigation gives, yet it will be admitted that a large part of modern engineering or metallurgical practice is based on facts discovered in physical and chemical laboratories.

Let us look for a moment at that greatest of all modern inventions —the Bessemer process—an invention which has made travel safer and more rapid, and cheapened all the necessaries of life. There never was a great discovery which was made known by its author in a more perfect and complete form than this; and yet for some time after it was in successful use very little was known of the chemical nature of the process. But the chemists were soon busily engaged with it, and the work which has been devoted to the explanation of the process the world over would fill many a ponderous volume.

Without this work the process would have made but slow progress, for unguided experiment would have been long in discovering what irons could be used and what irons could not. Chemical analysis soon was able to prescribe a formula for the pig iron adapted to the process and to predict just how each iron would behave. So completely is the process now understood that the softest iron and the hardest steel can be made by it at will. But the chemists did not stop here. Phosphorus was the element which had given the most annoyance in the process, and for a time it seemed definitely proved that only the pure ores—those free or almost free from phosphorus—could ever be used

in the process. But the chemist is fertile in resources and a tireless worker, and to-day we have a variation of the Bessemer process, which ranks as a new industry, and the corner-stone of the process is phosphorus. I know of no more interesting chapter in iron metallurgy than that which traces the development of this "basic process," or one which better illustrates the value of chemical investigation in industrial operations. This is but one instance. Chemical analysis is now indispensable in all metallurgical operations, and, in fact, the chemist's work is at the foundation of all trade and commerce.

The physical laboratory should command our attention equally with the chemical. Here is studied the relation of the molecular structure of metals to strains, heat, electricity, etc., and when the results obtained in the physical laboratory are correlated with those from the chemical laboratory we have the necessary data to guide us in the preparation of the metals. There is no doubt that the time will come, and many of us will live to see it, when iron and steel will be made on a formula like a physician's prescription. We are not quite ready for it yet, for there are too many unknown quantities entering into the problem. When the schools establish laboratories for research the necessary facts will soon be forthcoming, and our amazement will be great that we groped so long in the dark when the light was so near at hand.

The physical work on iron and steel which has been done in the present generation is enormous, and much of it has been work which could have been done in the physical laboratories of technical schools. Recall the knowledge we now have of the properties of hard and soft steel, of the effect of punching, hammering, and other mechanical treatment, of the fatigue and wear of metals, and of their adaptation to special uses.

We might talk by the hour of the subjects which could be advantageously and appropriately investigated in the school laboratories, in electricity, pneumatics, hydraulics, etc., but enough has been said to indicate that laboratory research lies at the basis of all progress in the arts.

To resume. The ideal technical school is one which is entirely distinct from the industrial school and is thoroughly professional in its character. Qualification for admission should be a preliminary course in college or scientific school, or its equivalent, and the student should at once begin work in the laboratories. His work should have the double object of giving him practice in manipulation and an insight

into the methods of research. He should be interested in the results obtained, which he should regard as positive contributions to accurate knowledge, even though they should be negative with respect to the particular investigation.

I know of no work of a teacher which requires more delicacy, firmness, and sympathy than guiding a student in work of this kind. Class teaching is here out of the question, and the pupil must get his inspiration directly from the master. He may have to encourage by practical help those who are disappointed in the results of their work or who grow weary in waiting. He may have to discourage those who are over-confident and hasty in anticipating results by allowing them to go astray until they find themselves hopelessly involved in difficulties. He must watch carefully the mental attitude of the student to find out whether he is striving to prove a theory or whether he is simply desirous of discovering the truth. It is a grand work for one who is fitted for it and whose life is given to it. No teacher in other departments sees so quickly the result of his training or is so sure of his reward.

The desire of many teachers to bring their pupils to their own standard induces them to lead the students over the ground which they themselves have gone. This is clearly a faulty method. A wise instructor will take a student quickly through the past so as to enable him to understand the present, but he will not let the student linger too long. We would not undervalue the work of the historian, but we would not have this work supersede the process of making history. The collection of knowledge and its systematic arrangement is valuable work, but it must soon come to an end if knowledge does not increase.

Technical schools should also offer opportunity for their graduates to continue their work. Fellowships should be founded to encourage graduates to remain in the school and aid in the work of instruction, for the system advocated necessitates a large number of teachers and overseers. Provisions should also be made for the temporary accommodation of experts who wish to make special investigations. Busy practitioners are seldom able to have well-appointed laboratories of their own, and would rejoice if the chance were offered them of working in those of the school.

Will it be said that this scheme savors more of a school of pure science than of science applied to the arts? Far from it; it is intended

to be intensely practical. It is impossible to draw any sharp line between pure and applied science, for the science which is abstract to-day may be embodied in a patent to-morrow. Modern electrical practice had its rise in Franklin's kite-flying and Galvani's diversions with frogs. The methods of experimentation are the same in both, but a wise teacher will confine a student's work to those subjects which have an obvious bearing on the practical arts.

The ignorance of the graduates of technical schools of the simplest practical procedures in industrial works has often exposed them to ridicule, and many schools, in consequence, have added work-shops and furnaces and engines to their equipment to give the students a general idea of machines and tools before sending them forth to work. This combined course of study and practice has earnest advocates among those who have tried it. And yet these school-shops and school-furnaces would never, I think, have been built if it had been understood at the start that the graduate did not pretend to know anything about the routine of the shop, and that he expected to learn his trade like any one else. Playing practice is not only useless—it is hurtful. If the student enters the works with mere book knowledge he spends considerable time in trying to see the bearing of his studies on the practice of the art. If left to his own resources it is about an even chance whether he succeds in this attempt or gets discouraged with practice (and perhaps takes up teaching), or throws aside his books and regrets the time he spent over them. The saying that one must *un*learn, when he begins to work, all that he learned in the schools has done much harm, but there are not a few practical illustrations of the saying. One might as well say that arithmetic was all very well in a school, but for good, square, accurate calculation a man had better confine himself to counting on his fingers or notching a stick. He who begins work with some preliminary training in the school-shop has, it is true, a better start, and there is perhaps less likelihood of his being discouraged by unfamiliar surroundings.

Very different is it with him who enters the mill or machine-shop after a long experience in physical and chemical research. His trained mind and senses detect relations and incongruities of which another would not be conscious. He has already learned to trust his own observation and judgment and to know their limitations. If a process is imperfect he quickly decides in what direction investigation is needed; he loses no time in fruitless experiment; he knows when he has enough

facts to form a theory of causation and when he has enough to determine definitely the cause. He is not misled by apparent economies; he is not satisfied until he knows the precise efficiency of a machine; he gives "undetermined elements" no chance to play important roles, for he convinces himself of their presence or absence. Far from this training in investigation making him an impracticable theorist, he is fairly hungry for facts. It makes little difference to him whether or not he ever handled a steam engine in the school or worked at a lathe; this is experience which he can quickly gain if his inclination or duty calls him to this work.

This advanced position which we would give to technical schools may render it desirable that the industrial or shop-schools should be multiplied. At all events, it is well to maintain that there are schools —call them by which name you will—which give the higher professional training in practical science as distinguished from shop-training. Let him who will fit himself for a master mechanic get his training in the industrial or shop-school, and him who wishes to be an engineer get his training in a technical or professional school, but let neither one complain that he did not get in one school the kind of training peculiar to the other. Fortunate is the man who has the time and means and desire to go through both these schools.

The equipment of a school of research will naturally consist mainly in apparatus designed for special investigation. There will be, of course, the usual apparatus for accurate measuring and weighing in the routine processes of physics and chemistry, but there will constantly arise the necessity for the construction of special apparatus, and this is in itself a great assistance in the training of students, who not unfrequently get the idea that the bright apparatus which fills the cases of college collections are the working tools or machines of the physicist, when they are merely his apparatus of illustration.

An investigating mind never grows old. We speak often of old-fashioned engineers, men not "up to the times," men who distrust modern ideas and hold to the methods of a past generation. These men were "up to the times" once, but because they simply learned the practice of their day and failed to catch the spirit of its growth, have been left behind as practice advanced. There is no danger that the student trained in research will ever get "behind the times." It should not be the aim of any teaching to put old heads on young

shoulders, but rather to keep young the heads which rest on old shoulders.

We can well understand the anxiety of the painstaking teacher who wishes to give his pupils as large an outfit of useful facts as possible; and yet if we reflect on the immense accumulation of facts in practical science, what does it matter whether the student gets a few more or less when the time of acquiring these facts might be devoted to learning the methods by which these facts were discovered? It would be poor policy to devote time to the practice of forging nails one by one, instead of becoming familiar with a machine which makes them by thousands.

It cannot fairly be said that the development of technical schools into schools of research would remove them farther from practice of the arts which they were instituted to foster. It is true there has been a break between the works and the school, but the gap has widened only to be narrowed again in the formation of a new and closer union. To make this union more complete the schools should be prepared to undertake practical investigations for the works. It is fitting that the schools should undertake such investigation for the professors are trained to the work and devote their lives to it. Many of the experiments made at works are imperfect, incomplete, or even inaccurate, because the person in charge of them does not know how to go about this kind of work, or is busy with other things.

The condition under which the school should undertake investigations for the works are:

1st. The subject should give fair promise of developing new and valuable information.

2d. This information, when obtained, should be published by the school.

3d. There should be no charge for the service.

If the schools did reliable work there would be no lack of material for investigation, and it would not be long before the supposed benefit derived from business secrets would disappear in the general diffusion of information.

Spontaneous evolution develops both useful and worthless variations; natural selection determines the survival of the fittest of them. Evolution by design, limits the production of useless forms and is thus more economical of power and time. Empirical development in the arts may aptly be compared with spontaneous evolution, while scien-

tific research controls and guides the development. The technical school should be a centre of evolution by design.

Engineers have in late years implored Congress on behalf of science, on behalf of the welfare of fifty millions of people, to establish a board for testing, on a large scale, iron, and steel, and other materials of construction, that our buildings may be more secure, our bridges safer, and our boilers less liable to explode. After a brief and useful career the first United States Board expired, and no favorable legislation has been obtained to revive it. The general arguments urged in favor of the government undertaking this work, are that the outlay necessary would be more than most individuals or corporations could afford, and that business interests would prevent a combination of manufacturers for the sake of so beneficent an object.

Is it too much to expect that some friend of the higher technical training will be found to endow a testing department in a technical school? This is the proper place for accurate experiment, for here we have the men trained to the work. Removed from all the disturbing elements of trade, from the influence of politics, and from the jealousies of engineers, the testing department of a technical school could, by reason of its permanence and independence, do work which would find universal acceptance. I think the suggestion worth the consideration of the Alumni of Lehigh University.

I have sketched what I regard an ideal technical school. But the sketch is only the embodiment of tendencies plainly to be observed in our most advanced schools. The course which Lehigh University has always pursued in maintaining a high standard of scholarship, the work of research of her instructors and students, the increase in her great library and the extension of her laboratories, indicate that she is advancing steadily and surely towards the realization of this idea—that technical schools should be an assemblage of workers in experimental science.

What, it may well be asked, is the meaning, and what is to be the result of all this restless activity in the arts? The mechanical engineer studies the phenomena of combustion, the properties of vapors, and makes his mechanism more sensitive and accurate that less coal may be used to drive his machinery. He is saving power. The chemist works on the crude ores and rocks, and on vegetable and animal products, to extract as completely as possible the substances useful to man. He is saving material. The engineer makes the rough places smooth,

hews paths in the solid rock, and hangs road-ways in the air. He is saving time. Where does man learn this lesson of economy? Nature appears to him as a spendthrift, counting material by worlds, prodigal of unlimited power, and reckoning time as a moment bounded by eternities. Why does man spare and store? Is he better or happier for it? Suffice it, in answer, to say that he obeys an instinct of his nature as irresistible as that of self-preservation. It is, in fact, for his own protection that he accumulates wealth in its various forms of substance, power, and time. We may not sit in judgment on this instinct and call it selfish,—it is for the *use* of his wealth that man must give account.

But we surely cannot fail to recognize the progress that man has made in the beneficent use of power. Are there not evidences on every side that many find greater pleasure in the unselfish use of wealth than in its acquisition, and are we not justified in expecting a time when man shall use his power only for good?

But is this restless activity never to cease? Are we progressing towards a millennium when the very earth shall tremble with the workers in its mines, when its surface shall be a tracery of rails and wires, when the roar and clatter of machinery shall deafen the ear and the smoke of countless chimneys obscure the light of the sun? Is there never to be rest from toil? It is a short and imperfect vision that thus divines the future. Each form of power advances to its own extinction in giving birth to subtler forms of power. Each mechanism is in time abandoned to give place to more effective machines.

Would you realize what power man has grasped, go to the forge and watch him as he, single-handed, directs the mighty hammer which, as if half ashamed of its great strength, coaxes the yielding iron into shape!

It scarcely needs illustration to prove that the tendency of material progress is toward the replacing of the mediate by immediate use of power. Perhaps few of the toilers recognize this tendency, but the more thoughtful and far-seeing look ahead to the promised day when, "if man shall say to the mountain, 'Be thou removed and be thou cast into the sea,' it shall be done."

This kind of faith and power, we are told, cometh only with patient, self-sacrificing seeking. It is a favorite figure which represents man wresting from nature her secrets and treasures by dint of persistence and prowess. Nature is never conquered by defiance; she surrenders

only to those who first surrender to her. It is the victory of obedience which man gains over nature, and it is the patient seeker after the truths which she carefully guards who is rewarded by her bounty and whose commands she obeys.

We smile as we read of the conquering hero of old, who, elated with his victories over man, commanded the waters of the sea to obey him. And yet we say to the lightning, "take thou my message and carry it to yon distant city;" and scarce have we uttered our command when we hear the voice of the fleet messenger—"thy servant brings thee answer."

The tendency of both material and spiritual progress may be summed up in the one word *knowledge*, for it is only perfect knowledge that renders perfect goodness possible. Is there a nobler career for a young man to select than one devoted to the discovery of nature's laws, and their application to the good and happiness of man? And is not this the life of the miner, who puts nature's reserved wealth into circulation; and that of the chemist, whose touch transmutes into value the dust of the earth; and that of the engineer, who, in annihilating space, makes one all nations of the earth?

It is well for us at times to take our thoughts from our own special and partial work to contemplate a broader horizon which includes with our work the work of others, and to see the harmony which arises from the fitting of related truths. Sometimes we think we get a glimpse in this harmony of a part of a great design, which makes our souls long for the time when in the perfect knowledge of God's laws, we shall have a revelation of His purpose.

Radiation of Silver at the moment of solidifying.—At the International Electrical Congress, in 1881, J. Violle proposed as an absolute photometric standard the radiation of a square centimetre of melted platinum. Dumas approved of the proposal, and at his invitation Violle performed some preliminary experiments with silver. From the moment when solidification begins, in contact with the containing vessel, until the whole becomes solidified, the radiation of the liquid part remains constant. The constant portion of the radiation is so sharply defined that silver may furnish a secondary fixed standard, which will be especially convenient in all the measurements of spectrophotometry.—*Comptes Rendus*, April 9, 1883. C.

MINING AND STORING ICE.

By W. P. Blake, F.G.S., New Haven, Conn.

[Read at the Boston Meeting of the American Institute of Mining Engineers, Feb., 1883.

We are so familiar with water in its liquid and its solid form, that we seldom think of it as a mineral, and still less as a mineral product of any considerable industrial importance, which in the form of ice is mined and stored up in enormous quantities yearly. The industry is peculiarly American, and in no other country has the business of cutting and storing ice been so well systematized and perfected. The interest has grown steadily from year to year, until it has attained large proportions, the annual production being counted in millions of tons, requiring in the aggregate, a large investment of capital in all the Northern States. It gives employment, also, to thousands of men and horses, in the depth of winter, when farming work cannot be carried on. Ice is not only a luxury, but a necessity, in our climate, and is indispensable in many manufacturing operations, and finds constantly increasing applications and uses. As the industry has grown, so the necessity for suitable implements and tools has grown with it, and it has become necessary to systematize and cheapen the methods of handling such a large amount of material with rapidity and economy.

As the industry is properly a branch of *mining*, and as our mining literature does not, to my knowledge, contain any description of the methods and appliances used in it, it seems desirable to place a brief description on record in our *Transactions*, I therefore offer to the Institute the following outline description, based partly upon observations for several years past of the methods and processes employed, and partly upon the information obtained from prominent ice-miners and from the manufacturers of ice-tools. My acknowledgments are particularly due to the firm of W. T. Wood & Co., of Arlington, Massachusetts, for much information in detail, and also to the Knickerbocker Ice Company, of Philadelphia. The wood-cut blocks used in the illustration of this paper, have been kindly lent by both of these firms.

The sequence of operations in getting ice is as follows:

1. Wetting down a light snow.
2. Scraping off an excess of snow, if present.

3. Marking out the field.
4. Ploughing and cross-ploughing.
5. Cutting the channel and detaching large floes.
6. Floating the floes to the channel.
7. Splitting off long strips of blocks.
8. Floating them to the foot of the elevator.
9. Dividing into single blocks.
10. Elevating the blocks.
11. Receiving the blocks at different platforms and sliding them into the houses.
12. Storing the blocks in regular tiers in the ice-houses.

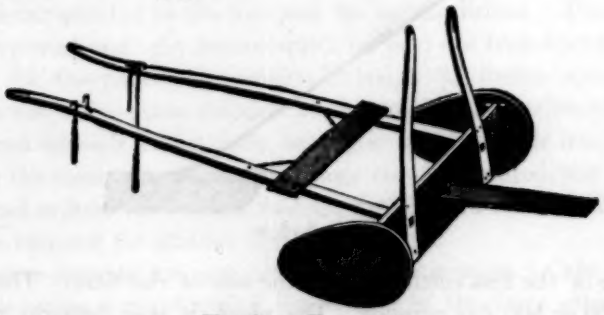
PREPARATION OF THE FIELD.

To insure perfectly clean and pure ice, pure, clean water is the first essential. Next, it is important that all dust and dirt shall be kept from the surface of the ice while it is forming and during harvesting. These conditions are best secured by a mantle of snow over the country which prevents dust from being swept upon the ice by the winds from adjoining roads and fields. But snow upon the ice is undesirable, although when the winter is open and ice does not form of sufficient thickness for economical harvesting a covering of snow may be utilized by flooding or "wetting down," as it is termed, so as to gain a greater thickness of ice. This flooding is accomplished by a number of men with ice-chisels, who traverse the ice-field in parallel lines about six feet apart, and punch holes through the ice at intervals of six feet as they advance. The weight of the men causes the ice to bend downwards, and the water rising through the holes penetrates and is gradually absorbed by the snow. The action is slow, and the snow is reduced in bulk to one-third or even one-quarter of its thickness when dry. The same operation is sometimes executed, not to gain an increased thickness for harvesting, but because the ice may be too thin to permit the horses to be used upon it; and often because an inch or two of snow ice is regarded as an advantage in protecting the clear ice below it from thaws before a good thickness for cutting is reached, and also because it makes the cakes of ice tougher and less liable to breakage in handling. But a full thickness of clear ice—from twelve to fifteen inches—and without a heavy covering of snow is the most desirable form in which the ice can be had. This, however, is rare.

Probably such a favorable state of the ice is not realized oftener than once in ten or twelve years.

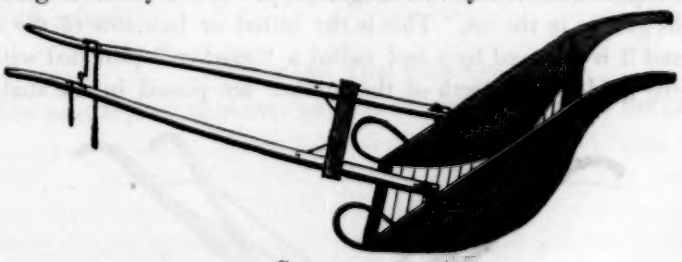
After the first light snow is wet down, and before the ice has fully grown to the desired thickness, other snows may accumulate, and must be removed before the operation of marking out and cutting commences.

Light dry snow is scraped off by means of scrapers or scoops, which vary in construction in different places, but are arranged to be drawn by horses. A common form of clearing-off scraper six feet long, is shown by the annexed figure.



Clearing-off scraper.

Heavy snow requires a scraper formed like a scoop, so that the snow may be moved in it to a considerable distance. The scoop-scraper is generally three feet wide and is fitted with an iron or steel-edge plate. It is shaped as shown in the figure, and besides the ordinary use for cleaning off heavy snow it is used to take away the wind-rows of snow



Scoop-scraper.

left by the clearing-off scraper. On small ponds it is necessary to dump the snow on the shores, but on large lakes and rivers where there is an abundance of room the snow is dumped at one side out of the way.

MARKING OUT THE ICE.

The ice being cleared of snow the next operation is marking out of the field, preparatory to cutting.

There are various ways of striking the first line. Some stretch a line between two pins set, say 200 feet apart, and then follow this line by a "marker" carefully guided by the hand so as to preserve a straight line. Others use a straight edge of plank fitted with sights, and this is the best method. Two stakes are first set up in the desired

Hand-plow.

direction of the first cutting and at the side of the field. These may be set 500 or 600 feet asunder. The plank is then brought into line between the stakes, by means of the sights set in each end. A hand plow is then run close to the edge of the plank from end to end, following it as a ruler is followed by a pen or a knife. When a straight groove is cut about half an inch deep, the plank is moved one length ahead and is again brought into line by the sight, and so on the operation is repeated until the full length of the line is marked out by a straight groove in the ice. This is the initial or base-line of the cutting, and it is followed by a tool called a "marker" provided with a swinging guide. The teeth of the marker are placed in the shallow

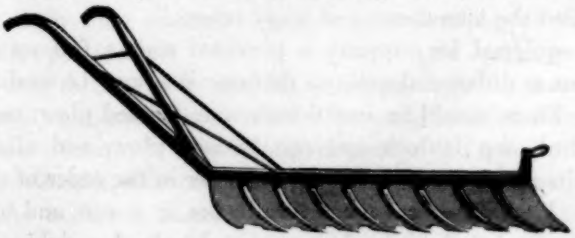
Marker, with swing guide.

groove and run across the field, deepening the groove to three inches and leaving it $\frac{7}{16}$ths wide. During the progress of this first cut, the guide is either taken off or is allowed to slide alongside on the smooth ice with the handle thrown out of the retaining-notch, the tool being guided by the eye and hand of the operator, aided by the groove. In this manner one straight groove three inches deep is made across the field at one side. The guide is then brought into use and is swung over the back of the marker and takes its place in the groove. The distance between the guide and the teeth of the marker is generally 22 inches. The tool is then drawn back across the field and a second groove is cut parallel to the first and 22 inches distant. This operation is repeated until the desired width of field has been traversed and marked by the parallel grooves. Although 22 inches square is a common size of ice-cakes, shippers of ice usually cut their ice 44 inches square and house it in this form, cutting it up afterwards into 22-inch cakes in the summer. When this large size is required, the guide is set 44 inches from the marker, and the field is then marked off in half the time required for 22-inch marking.*

The cross-grooves are next cut in a similar manner. Care must be taken to secure a right-angled intersection of the front cross-groove with the others. This result is usually secured by a large wooden square, placed on the ice with one edge laid along the first groove, while sighting along the other edge to get the position of the stake. A better method would be to use a line and strike two curves as in draughting, so as to strike a perpendicular. With two marking tools the two systems of lines can be run simultaneously, and much time may be gained.

PLOUGHING THE GROOVES.

The next tool brought into use is the ice-plow, by which the grooves



8-inch plow—8 teeth.

* For further observation on the size of the blocks, see *infra* pp. 365–366.

made by the markers are cut to the required depth, generally to about two-thirds the total thickness of the ice.

The ice-plow is a very important instrument and has finally reached a highly perfected form, as the result of many years of experience and effort. Its invention and first manufacture dates back as early as about the year 1839, and it has now generally superseded the use of the saw and the axe for cutting ice.

The form and construction are indicated by the figure. It consists of a succession of curved, blade-like teeth, attached to a long beam with interspaces in the teeth for the escape of the ice chips. These teeth are now so formed as to clear themselves and carry the chips neatly out of the groove with little resistance. In noting the progressive improvement of ice-plows, I cannot do better than to quote from the description given by Messrs. W. T. Wood & Co., of Arlington, Massachusetts, where the manufacture of ice-tools was established in 1834. "The plough was first made with wooden beams and with iron teeth, steeled and widened or upset at the point only. Next, iron beams of equal width were substituted for the wooden ones. Then followed various alterations, such as flanging the teeth the entire face so as to carry out the chips; making one beam wider than the other, to give room for the chips on one side; cutting out chip-spaces in the narrow beam, thus allowing the chips to shoot out freely from between its teeth and permitting the plough to run to its *full depth;* cutting out the bottom of the teeth, leaving only the heel and point to be fitted; making the best ploughs of *steel* teeth instead of iron and steel; improving the curve of the teeth; increasing the degree of finish, etc., etc." "Amongst some of the further experiments referred to may be mentioned, double-markers, combination plane and marker, teeth shaped like a lumber-marker, slanted back so as to *draw* through the ice, plows with sixteen teeth, gouge-pointed teeth, teeth with grooved spaces, called the lateral-cut, and many others."

A well-equipped ice company is provided with a full set of plows made to cut to different depths, so that one size may be used to follow another. There should be one 6-inch nine-toothed plow, one 8-inch, eight-toothed, one 10-inch and one 12-inch plow, and all of them used simultaneously, each following the other in the order of the depth of tooth. Each plow cuts about two inches at a run, and by having a full set and using them in sequence as described, a field of ice can be grooved much faster than where one plough has to do all the work.

CUTTING A CHANNEL.

While the ploughing is in progress, or before, a channel is cut through the ice between the cutting ground and the incline or elevator, by which the blocks of ice are raised and delivered to the ice-houses. This channel is cut by plows which are allowed to cut nearly through the ice. The grooves so made are followed by saws, which complete the separation. A narrow strip of ice is thus cut free from the surrounding surface, and is then pressed down and under the main ice sheet, and a wider strip can then be cut loose and sunk, or harvested if suitable.

The channel being opened, and the elevators in readiness, the next operation is to detach large floes of the grooved ice and float them towards the elevator. This is accomplished by first sawing in the grooves across the ends of the block or "float" desired. Such a float, if there is sufficient space, may be 100 feet or more in length, large enough to sustain the weight of several men. It is common to cut them seven or eight cakes (of 44 inches square) wide, and ten or twelve cakes long. The sawing is done at right angles with the open water-space into which the floes are to be forced; there is thus but one long side to be detached, and this is split off the main body by "breaking-bars," broad wedge-shaped chisels. It is sufficient for

Breaking-bar.

workmen to follow along one of the grooves and to plunge this broad wedge into it at intervals with considerable force; a crack is thus started and can be followed up and extended the full length of the floe. When the separation is complete, the mass slowly floats away into the open space, and is directed through it to the channel by the workmen with long ice-hooks, or by lines extending to the firm ice around the open space.

The floe is then to be divided up into long strips, by means of fork-bars; three men striking together in the same seam at intervals until the strips are detached. These may be one or two cakes wide, according to the elevator, either single or double. These long strips are then floated into a narrow channel leading up to the foot of the elevator, and as they pass along, one or two men stationed at the side of the canal on a plank platform, separate the cakes by striking lightly in the

transverse grooves with a "canal-chisel," a tool six feet long, with a hollow handle to secure lightness.

Canal-chisel.

The whole of this series of operations, together with the arrangement of the elevators and ice-houses, are well shown by the wood-cut for which I am indebted to the courtesy of the Knickerbocker Ice Company of Philadelphia.

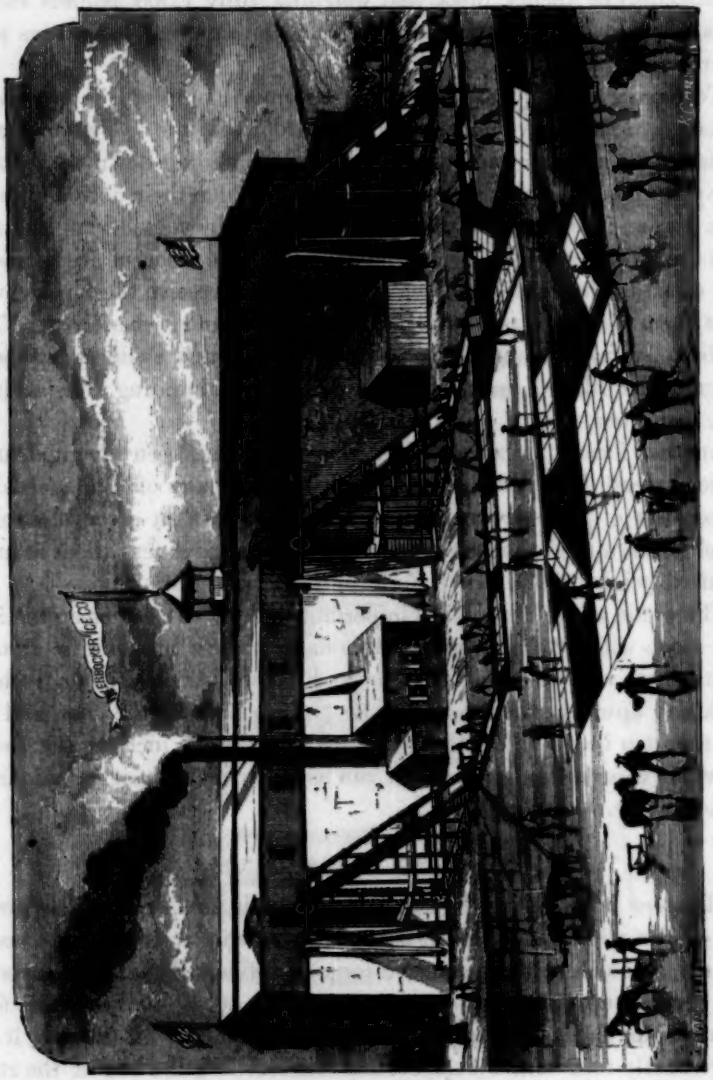
ELEVATION OF THE ICE.

The ice is lifted from the water by steam-power high enough to be distributed on ways, by sliding, into any part of the ice-house. The apparatus generally used is an endless-chain working on an inclined plane, the lower end of which dips below the surface of the water. The chain is double, consisting of two single chains side by side and about five feet apart, for 44-inch cakes, with wooden cross-bars connecting the chains at intervals of 6 feet. Large, open, rectangular spaces or links are thus formed large enough to admit a cake of ice between the bars, which extend across between the two strings of the chain.

The ice-cakes, as they are separated from the long strips in the channel, are pushed forward to the foot of the inclined plane over which this chain is moving, and being caught by the cross bars are carried along up the incline, each link or space on the chain taking one cake and depositing it at the first opening made in the floor of the incline, the cakes dropping through upon the platform of a second incline or guide-way with a gentle descent in the opposite direction, leading into the building. A series of such platforms and guideways is requisite. They are built one above another, about six feet apart, until the upper one will deliver the ice to the highest point, or layer, to be filled in the building. The lowest comes first into use, and the others in succession, as the building fills up with ice. Usually four runs are sufficient. When there are several ice-houses placed side by side, the guide-ways or runs are made to pass the doors of all the houses, and the ice can be turned at pleasure into any of the houses.

The construction of an overshot inclined plane elevator and endless chain is shown on the accompanying cut, showing also the driving

pulley and gearing. It is arranged with a stairway alongside the chain for the convenience of the workmen. Six platform-runs are shown, the lowest one only being prolonged to the ice-house.



Ice-cutting scene, with the endless chain in operation.

The elevator-chain is moved by steam power. The speed varies at different places and under different conditions. The highest rate of

movement brought to my knowledge was obtained on one chain (with five-feet spaces for 44-inch cakes and the cross-bars six feet apart) where 50 blocks were raised to the minute, each block being 44 inches square and 15 inches thick and weighing fully 1,000 pounds each. This lifting was thus at the rate of 25 tons a minute or 1,500 tons per hour.

To receive and stow away such an enormous supply, it is necessary to have at least twelve doors or houses to deliver into. Two men are stationed at each door, and as the cakes of ice sliding down the guide-way pass the door-way, the men select the cake due their door and pull it in by means of ice-hooks upon a branch guide-way or run leading into the building. When once landed upon the floor of ice already laid down in the house, the men stationed there receive the blocks and slide them into their proper places, side by side and tier after tier. To facilitate storage in large houses, movable slides and switches are used to guide the cakes of ice to different parts of the building, thus saving time and labor.

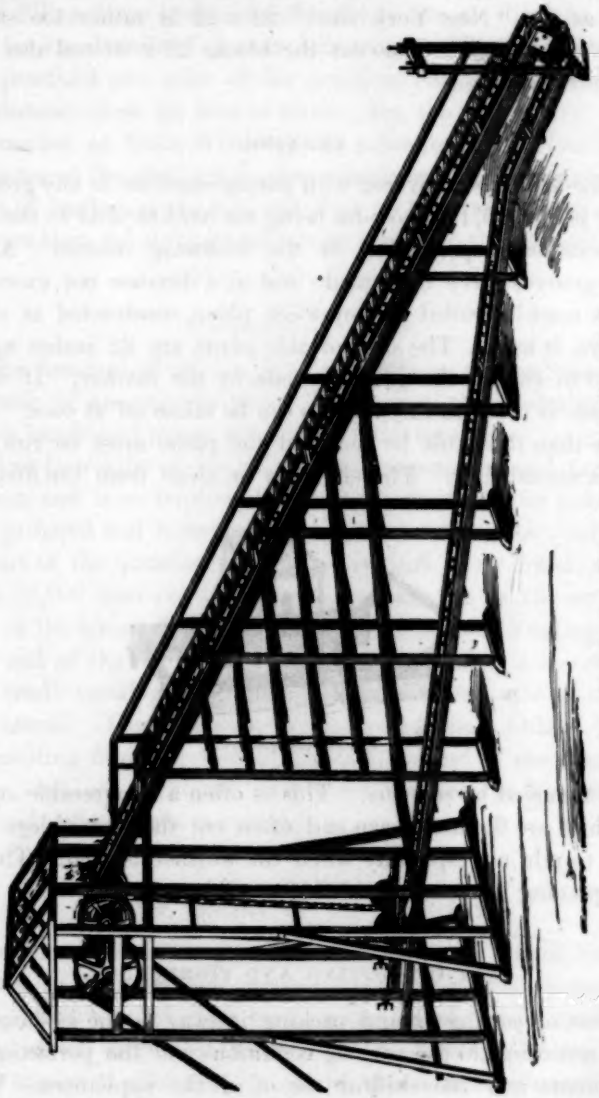
Another form of apparatus for lifting the ice has been invented, and is recommended by the Knickerbocker Ice Company of Philadelphia. It consists of a revolving vertical spiral platform, a screw elevator, which takes up cakes of ice from the water and delivers them at any required height to the runs leading into the ice-house.

The grade of ice-runs is an important matter. If too steep the ice will move with great velocity, and be more or less broken up; if too slight, there will be a loss of time and labor. With ice ten inches thick and upwards, the grade may be $\frac{5}{8}$ of an inch to the foot, and if less than ten inches thick, the grade may be $\frac{3}{4}$ of an inch to the foot. In warm weather the ice does not run as freely as when it is cold, and the ice is dry.

ICE-HOUSES AND STORING.

The most improved ice-houses are now built 100 or 150 feet long and 40 feet wide. This width is found in practice to be the most convenient, so much so that even if a large house is built under one roof, it is divided up inside into apartments from 36 to 40 feet wide, for when the ice slides down the centre-line of the house on the run, it is conveniently near either side, so that on reaching the end of the run (made in ten-foot sections) it is easily directed or "shunted" to the place it is needed to fill.

In storing, the cakes are placed so as to leave a 3-inch space all around them to prevent undue wasting when they are broken out in the summer season for delivery. It therefore becomes necessary to



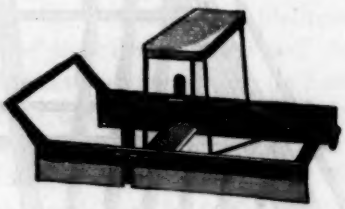
Overshot inclined-plane elevator and endless chain.

break joints every few tiers as they are laid up, by lapping the cakes over in such a way that the joints are covered. In Maine it has been

the custom to cut the cakes of ice 44 x 22, thus giving a rectangular block, with which it is easy to break joints in packing. It is now, however, becoming common on the Kennebec to cut the blocks 22 x 32, known as the "New York size;" 22 x 22 is rather too small, and 22 x 44 is too large. Some cut the blocks 22 x 30 and also 22 x 28, but all for shipping.

PLANING.

The ice-field when covered with porous snow-ice to any great depth, must be *planed* off, the snow-ice being too hard to yield to the scrapers. The operation is performed in the following manner: After the marker-grooves have been made and at a distance not exceeding 22 inches, a machine called the snow-ice plane, constructed as shown in the figure, is used. The sides of this plane are 22 inches apart and are fitted to run in the grooves made by the marker. If drawn by two horses as much as three inches can be taken off at once. If more snow-ice than this must be removed the plane must be run over the surface a second time. The shavings or chips from the first planing



Snow-ice plane.

must be removed by scrapers. This is often a disagreeable operation, as the chips are flat and sharp and often cut the horses' legs and are difficult to pile up, especially when the weather is cold. The operation of planing is always avoided if possible.

COST OF CUTTING AND STORING ICE.

The cost of cutting ice and packing it away in the ice-house varies greatly, according to the varying conditions and the perfection of the arrangements and the skillful use of all the appliances. With an unlimited supply of good ice, say 10 to 12 inches thick, the cost may be as low as 12 cents per ton. At an ice-house where some 10,000 tons

were harvested during the past winter the cost was estimated at 15 cents per ton. The average cost is nearer 25 cents.

When the crop is abundant it is not unusual for the owners of the plant for filling large ice-houses after the houses are filled, to continue cutting for the benefit of persons who wish to fill private ice-houses. This is practiced near some of the populous cities and villages within carting distance from the lake or river. Ice, the past winter, was sold in this manner at Lake Whitney, two miles from New Haven, at 40 cents per ton on the platform by the roadside ready to load into wagons. The cost of carting to the city was from 50 cents to 60 cents per ton, being more than the cutting and raising the ice to the platform.

WASTAGE AND LOSS.

But the first cost of the ice, as stored away in the ice-houses, is not a just basis of an estimate of its final cost to the ice-dealer when it leaves his hands and passes into those of the consumer.

The loss in weight of ice by melting, evaporation, and breakage is very great, and is an important item in the business, for although ice may be gathered and housed at an apparent trifling cost, only a fractional part of the quantity harvested is utilized. One dealer, who puts up some 10,000 tons yearly, estimates the wastage at 25 per cent. by melting in the houses during the season, 25 per cent. in taking out and carting, and of the remaining one-half there is often a loss of 33 per cent. in retail vending, or a total wastage of four-sixths of the entire amount stored. This is probably a large estimate. Others place the loss by melting from the close of winter to the end of the season at 25 per cent., and an additional loss of 25 per cent. to 30 per cent. in carting and delivering to consumers.

CHIEF CENTRE OF ICE INDUSTRY.

It is estimated that the consumption of ice in the city of New York is upwards of 700,000 tons annually, with an annual increase of 15 per cent. There are fifteen or more ice companies, besides small dealers who buy of the large companies. The manufacture of artificial ice does not appear to affect the demand for the naturally-formed article.

The Upper Hudson is a great source of ice for the New York market. Those who travel between New York and Albany, either by boat or by

rail, cannot fail to notice the many large ice-houses which crowd the banks in some places from Troy and Albany as far down as Rhinebeck, Rondout, and Kingston. The river not only yields the product, but in summer gives it cheap transportation.

The conditions for the ice industry are thus exceptionably favorable. Full statistics for the present year* show that there are nearly two hundred ice-houses along the river, with a storage capacity of from 500 tons to 60,000 tons each. The total amount harvested this year is not less than 3,000,000 tons,—one of the largest harvests of ice ever gathered along the river. The ice-crop for the past six winters has been as follows:

Year.	Harvested Tons.
1878	2,408,500
1879	2,061,500
1880	150,000
1881	2,500,000
1882	2,000,000
1883	3,000,000

A considerable part of this ice was from eight to ten inches thick, and some of it was fourteen inches thick. The harvest commenced as early as December 8th, but a thaw interrupted the work, and it was not actively resumed until January 8th, 1883, and the principal houses were filled within the next thirty days.

A favorable winter for ice on the Hudson and an abundant harvest, makes it less desirable to lay in a heavy store at the ice-houses in Maine. On the other hand, an unfavorable season in New York is advantageous to the more northern dealers.

The Kennebec River in Maine is also a favorite region for harvesting ice. It has the advantage of rigorous winters and the crops rarely fail. The deep inlets and ponds give easy access to vessels and cheap transportation to domestic and foreign markets. Several of the principal ice companies of New York, Philadelphia, Baltimore, and Washington have large ice-houses along the stream and secure a supply there when the winter fails to give the required crop nearer to their consumers The greater part of the Kennebec, from Bath and Woolwich up to the dam at Augusta, is marked off to different ice dealers and is dotted with ice-houses. A map of this region, with a full list of the companies and firms engaged in the ice business, and statistics of the production

* Published by the Albany *Evening Journal*, January, 1883.

of ice in Maine, is published annually by Mr. A. G. Chase, of Gardiner, Maine. Considerable quantities of ice are gathered along the Penobscot, the Cathance River, and along the coast, as will be seen by the annexed summary for the years 1882 and 1883.*

Locality.	Year 1882.	Year 1883.
Kennebec	1,029,200	931,900
Penobscot	146,000	112,000
Cathance	39,000	22,700
Coast	349,000	297,900
Total, tons	1,563,200	1,364,500

The falling off is attributable to the abundant harvest on the Hudson and at other points.

Besides these main centres of the ice industry, ice-houses are scattered over the interior of the New England and Northern States, and full statistics of the annual ice production are not readily attainable. At New Haven, Conn., for example, the main supply is from Whitney Lake, where 10,500 tons were harvested this winter, and from Lake Saltonstall.

Upon the Pacific Coast ice for the San Francisco market is harvested in Alaska, partly at Sitka and partly at Kodiak, the winter at Sitka often not being sufficiently severe to make thick ice.

The ice interest of the country is sufficient to sustain a monthly paper devoted to the ice trade.† It is published by the Knickerbocker Ice Company of Philadelphia. This company is organized on a basis of $1,500,000 capital. It has 250 delivery wagons and employs 800 persons. The total annual ice-crop of the United States is estimated at 20,000,000 tons, and the consumption 12,000,000 tons, the difference being waste.

Phases of Electric Vibrations.—A. Oberbeck publishes investigations which lead to the following law: If electric waves, which are synchronous, but have different phases, flow through the fixed and the movable roll of an electro-dynamometer, the deviation of the movable roll is proportional to the product of the maximum intensity and the cosine of the difference of phase.—*Ann. der Phys. u. Chem.*, Nov., 1882. C.

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* Figures for 1882 from Chase's map, and for 1883 from the *Ice Trade Journal.*

† *Ice Trade Journal*, Philadelphia.

APPARATUS FOR ESTIMATING CARBON IN STEELS.

By Addison B. Clemence, Worcester, Mass.

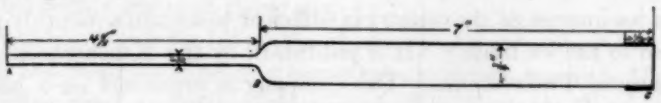
A description of the apparatus in use at the works of the Washburn & Moen Manufacturing Company, of this city, will, I think, be of interest to those who desire an accurate method for the estimation of carbon in steels. The apparatus has been in use in the works for the past three months, and has given entire satisfaction.

The method of filtering carbon on to asbestos in a glass funnel, drying, transferring to a porcelain tube, and burning in a stream of oxygen gas, is accurate if all the carbon can be separated from the sides of the funnel, which in some cases is almost impossible.

Again, the method of filtering on to asbestos in a platinum tube or boat-shaped apparatus, and putting all in a porcelain tube and burning as before, has also been used, and of course is less liable to error.

My aim has been to do away entirely with the porcelain tube and combustion furnace, and to filter and burn in the same tube.

The sketch shows the form of apparatus I have adopted, being made of platinum.



The following is the process I use: Dissolve from 3 to 5 grams steel borings in double chloride copper and ammonium, using 36 grams of the salt to 120 cc. water for 3 grams of steel.

After the separated copper has completely dissolved, filter on to a plug of ignited asbestos placed at (*b*), and wash thoroughly with hot water. Any carbon that adheres to the sides of the tube may be swept down with moistened asbestos.

The tube is then placed in an air-bath and dried at a temperature of 150° to 175°C. for about one hour. A hard rubber cork, through which is a glass tube, is inserted at (*c*), the oxygen gas passing from (*c*) to (*a*). Around the tube at (*c*) is a single thickness of filter paper, about two inches wide, kept wet by a stream of water supplied from a reservoir on a shelf above.

Heat is applied at (*b*) for one-half hour, at the end of which time

the potash bulb is ready for the balance. One Bunsen burner is sufficient for the combustion.

The same precautions are taken to dry the gas before entering the platinum tube, as well as before entering the potash bulb, as in the case in the porcelain tube method.

Six burners of a combustion furnace will consume 14 feet gas in one-half hour, while one Bunsen burner will consume 2 feet in the same time.

The following table shows some results obtained by the "platinum tube" process:

A is a Swedish Bessemer, with ·10 per cent. of carbon;

B an American Bessemer, with ·18 per cent., and

C an American Bessemer, with ·50 per cent., all obtained by the "porcelain tube" process.

	A.	B.	C.
1.....	·09	·18	·49
2.....	·10	·18	·51
3.....	·10	·16	·49
4.....	·10	·17	·44

NOTE.—If pure, closely-woven asbestos cloth can be obtained, I see no reason why with two potash bulbs, twelve combustions may not be made in one day, for each filter with its contents may, when dried, be put in the platinum tube and burned.

Worcester, September, 1883.

Incombustible Paper.—G. Meyer has submitted to the Société d'Encouragement specimens of incombustible paper and card board. The base of the paper is amianthus; but it was necessary also to invent inks which should be both indelible and incombustible and which could be employed in writing, printing, lithographing, etc. One of his lithographs when placed between two layers of melted glass resisted the action of heat. It remained uninjured and the engraving preserved all its sharpness.—*Chron. Industr.*, March 25, 1883. C.

AN ELECTRIC SIGNAL CLOCK.

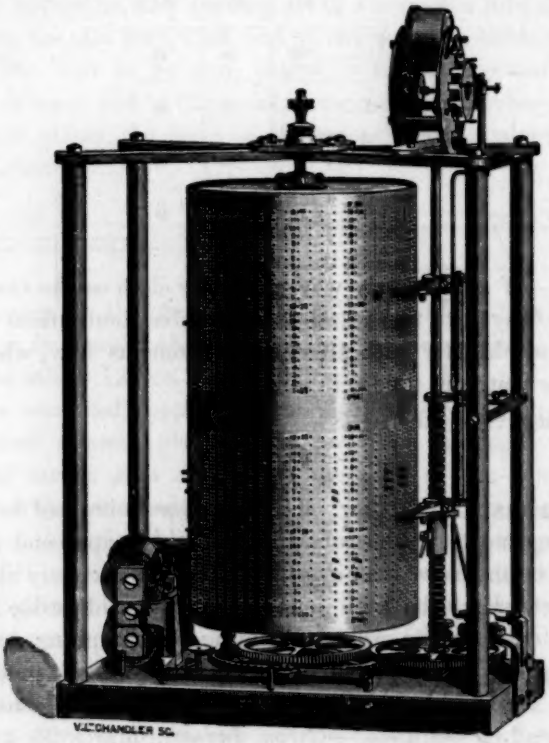
[Report of the Committee on Science and the Arts.]

HALL OF THE FRANKLIN INSTITUTE,

Philadelphia, September 5, 1883.

The Committee of the Electrical Section of the Franklin Institute of the State of Pennsylvania, to which was referred for examination Blodgett Bros., of Boston, Electric Signal Clock, report that they have examined the invention, and find its purpose and construction substantially to be as follows:

The instrument is designed—1st. To give any kind of fixed signals at any regular or irregular intervals, and especially, 2d. To cause the striking of warning and departure signals for railway trains or street cars, according to the time table in use. In general, it is intended for all purposes where any sort of time signals is required.



In the following, we give the peculiar features and manner of operation of the instrument.

An electro-magnet is connected by wires to a standard clock, which closes an electric circuit once every minute. This magnet, by means of a lever and a pawl, rotates a ratchet-wheel of sixty teeth one step each minute. The wheel is rigidly attached to the axis of a vertical cylinder fourteen inches high, and six inches in diameter, which revolves with it, and therefore makes a complete revolution once in an hour. The cylinder has two divisions, each of which is provided with a hole for every minute of twenty-four hours, or 1,440 holes in all, arranged in a single spiral.

A toothed wheel on the axis of this cylinder, gearing into another of equal size, imparts its motion to a coarse-threaded screw, which raises, at a rate uniform with the movement of the cylinder, a small sleeve or follower, consisting of a short lever with two arms, the forward end of which passes very near to the surface of the cylinder. The rear end of this lever is forked, and gives a lateral movement to an elongated crank, and also, by means presently to be described, to a vertical rocking shaft, bearing at its upper end a horizontal bar, adapted alternately to engage with and release stop pins of a circuit wheel.

Whenever the vertical shaft is slightly rotated, the circuit wheel (which is driven by a spring clock movement) is released, and moves on a short distance.

For railroad purposes, two signals are usually required for every train; a warning or preliminary signal, which precedes the other by an interval of from two to five minutes, and a final or departure signal, sounded at the exact moment when the train should start. To effect this operation, short pins are inserted into the holes of the cylinder, which correspond in location to the times of all the warning and departure signals. The lower division is arranged according to the week-day time-table, and the upper one according to the Sunday time-table. The follower passes over every hole in the cylinder once in twenty-four hours. When, in the course of its traverse, it comes in contact with the first of the two pins for any train, the end is moved away from the cylinder a short distance, and by a small rotation of the vertical shaft, deflects the horizontal bar far enough to allow a pin to pass, and thereby set the circuit wheel of the clockwork in motion. This wheel has upon its circumference a series of projections or pins, which, when the wheel revolves, come in contact with a fixed spring. The

projections and spring close an electric circuit through the signal bells a certain number of times, depending on the signal to be given. When the follower comes in contact with the pin denoting the time of the second or departure signal, the operation is repeated, except that there are a different number of projections on the circuit wheel, and so a different number of strokes upon the bells, corresponding to the distinctive character of the final signal. When the time of the next train approaches, the same movements are repeated, and so on through the entire day. At midnight the follower has completed its traverse of all the holes in the cylinder, and it is then automatically detached from the screw by a cam, and falls freely to its position opposite the first hole in the series, where it becomes again attached to the screw, and begins a new day.

A second follower, also connected with the elongated crank, moves in like manner over the upper part of the cylinder; but it cannot put in motion the striking mechanism during a week-day. On Sunday, however, it is rendered operative, and the lower one inoperative, in the following manner: Each of the elongated cranks, before described, is attached to a sleeve, fitting loosely on the rod, carrying the horizontal detent bar. It communicates its motion to this rod by means of a slot in the sleeve, engaging with a pin, running transversely through the middle of the rod, in such a manner that a slight movement downward of both sleeves, will disengage the lower one from the rod, and the pin will engage with a slot in the upper sleeve, which can then rotate the rod and detent bar, against which the stop-pins rest; while now the lower one turns freely about the rod, without affecting the mechanism in any way.

The weight of the sleeves is carried by a cam attached to a ratchet wheel of seven teeth, which revolves around the vertical rod. In the descent of the follower at midnight of each day, it moves this seven-toothed ratchet wheel and cam forward one space.

One-seventh of the circumference of the cam is depressed considerably below the level of the remainder, which is horizontal. The sleeves are supported by a pin, which during six days of the week rides upon the horizontal surface of the cam; but at midnight, Saturday, it falls into the depression, lowering the sleeves, and thereby disconnects the lower one from the vertical rod and bar, which control the striking mechanism, and engages the upper one. For this day, then, the pins in the upper division, corresponding to the Sunday time-table, operate the signal

bells, and those for the week-days have no effect. With the next transfer of the follower at midnight, Sunday, the pin is lifted out of the depression of the cam, and the week-day time-table is resumed.

These operations are repeated week after week, requiring no other attention than the winding of the spring of the clock movement which drives the circuit wheel, once a week, or at longer intervals, according to the number of trains.

There are some peculiar features to be noticed about this machine. Instead of the usual arrangement of a stationary magnet and a movable armature, the magnet which rotates the cylinder is pivoted on a vertical axis near the base of the coils of the magnet (which are in a vertical plane), and the armature is stationary. Both have curved surfaces, which are arranged eccentrically to each other, in such a manner that the movement of the magnet, when the current passes, brings it constantly nearer to, but never in contact with the armature. Its path is limited by a stop. When the electric circuit through the coils of the magnet is broken, a repelling spring returns it to its first position. The cylinder is prevented from moving backward by a fixed pawl engaging with the teeth of the ratchet wheel; and from going more than one space at a time, by a wedge-shaped projection on the pawl which rotates the cylinder, coming in contact with a stop at each movement, and preventing further motion of the wheel.

The operation of changing the time-table for a new schedule, consists simply in removing the pins, which are screwed into the cylinder, and placing them in new holes. The holes are numbered for every five minutes, to facilitate this operation. The number of signal strokes may also be easily changed for a different number of blows in the series, by simply substituting for the circuit wheel another with a different number of projections. Three or more blows may be given for each train instead of two, by proper arrangement of the projections on the circuit wheel, and corresponding limits of motion by the stop pins.

The instrument has no parts that are easily deranged, nor are its adjustments difficult to be made.

The wear is very slight, and the parts are all accessible for repairs, should any such be necessary.

Believing that Blodgett's Electric Signal Clock is not only an invention that will answer the purpose it is designed for, accurately and effectively, but that it also solves some complex mechanical problems

simply and ingeniously, we recommend that Blodgett Bros. receive the award of the Scott Legacy Medal and Premium.

Approved, September 5, 1883.

H. R. HEYL,
Chairman Committee Science and the Arts.

Attest: WILLIAM H. WAHL,
Secretary.

Book Notices.

THE WATCHMAKERS' HANDBOOK. By Claudius Saunier. Intended as a Workshop Companion for those who are engaged in Watchmaking and the Allied Mechanical Arts. English edition. Translated, revised and considerably augmented by Julien Tripplin and Edward Rigg, M.A. Illustrated by numerous wood blocks and copper plates. London: J. Tripplin, 5 Bartlett's buildings; and at the office of "The Watchmaker, Jeweller and Silversmith," 11 Saint Bride street. 1882.

In the Preface of this book the author makes the following assertion, which is strictly correct: "In recent years the work of ordinary watch-jobbers and repairers has undergone considerable change. The apprenticeship he serves, if indeed it can be called a real apprenticeship, is shorter than formerly. The immense number of badly constructed watches he is called upon to put in going order for a trifling remuneration compels him to replace the older methods of procedure by others whenever by so doing time can be saved." And we agree with him when he further says "that from this point of view the value of the present Handbook can hardly be over-estimated, since it contains, in readily accessible form, many details as to the working of metals and descriptions of various practical operations, new and improved forms of tools," etc.

The purpose of the book could not well be better defined than in the above-quoted words of the author. To all who lack the experience of a thorough apprenticeship in watchmaking this book will be a source of information well worth their attention. The contents embraces such information only as the jobber and repairer is especially in need of, and on matters belonging to horology as a science he fre-

quently refers to his "Treatise on Modern Horology," to which he considers the work before us a "companion."

The book is divided into six parts.

Part One, devoted to Arithmetic, Geometry and Measurement, giving short but very comprehensive instructions on these subjects.

Part Two, to the Materials used in Horology, how to prepare and treat them, what purposes they have to serve and where they are applied. The metals, the chemicals, the minerals and other natural products are sufficiently considered to serve the object of the book.

Part Three has "Health and Manipulation" for its subject, and gives brief advice and instruction on the different subjects which are well worth observing.

Part Four speaks of the outfit of the workshop in general, and is very important. It describes all necessary tools and appliances, and the manner in which they are used, minutely and well.

The subject of *Part Five* is the "Repairing and Examining of Watches."

The "Practical Receipts" of *Part Six* are a supplementary addition to the book, describing many practical ways of doing work not mentioned in the other chapters.

The book is a mine of useful information. Its illustrations are well executed and numerous, and the index enables one to find references readily. L. H. S.

THE NATURE OF HEAT AND GRAVITY. By William Coutie: Troy, N. Y.: H. Stowell, printer, 1883.

The writer of this pamphlet speaks of himself as "one who, in one point at least, was the first of all living men in the most difficult subject that has engaged the attention of this generation" (p. 18.) In this belief he is mistaken, for there are many men living who have entertained similar views, and his hypothesis, that light, heat, and gravity are "only different manifestations of the self-same thing," is at least as old as the days of Lucretius. It was virtually adopted by Newton, in his study of the laws of gravitation, and more fully and definitely expanded by Le Sage.

So far, however, as the hypothesis has been independently thought out, it has a special interest, as giving additional evidence of a natural, instinctive belief, which furnishes grounds for further investigation;

and so far as an attempt has been made at numerical confirmation of that belief, there has been a working in the right direction. For example, on page 10, the fourth postulate is as follows:

"The planets, in moving around the sun, have their motions reversed from direct right lines twice in every revolution, and by (3) the force required to do this is equal to four times the force required to impart to them their present energies."

The table of planetary data and of hypothetical resultant "reversing force," which accompanies and illustrates the postulate, however fanciful it may seem at first glance, may, perhaps, find some justification in the hypotheses of Siemens, in regard to the conservation of solar energy, and of Eddy, in regard to the questionableness of the second law of thermodynamics. Chase's application of the principle of "the dynamic head" to an explanation of the dependence of all the motions in the solar system on the wave velocity of light (*Proc. A. P. S.*, vols. ix–xxi), de Senlis's comparison of the sun to an incandescent electric lamp working in an absolute vacuum (*Les Mondes*, Jan. 6, 1883), and Duponchel's attempts to show how the heat which is emitted can return by a closed circuit to the focus of departure (*Revue Scientifique*, Jan. 27, 1883) may also be consulted in the same connection. C.

PAINTING AND PAINTERS' MATERIALS; a book of facts for painters and those who use and deal in paint materials. By Charles L. Condit, under the supervision of Jacob Scheller, master painter. Published by The Railroad Gazette, New York, 1883, pp. 461.

This is a very thorough treatise on an important, and by no means hackneyed subject—the treating of oils, etc., in relation to paints, varnishes, and colors; also directions as to decoration of interiors and exteriors, the erection and management of paint shops, the painting of railroad cars, carriages, etc. There are chapters on the manufacture of white and red lead, and their effects upon iron and wood, also a chapter on putty and brushes, and one on the much neglected subject of the effects of paint upon the health of the workmen. The testing of materials and the drying qualities of oils, turpentine and benzine, together with the proper mode of mixing colors to obtain certain shades, are subjects treated in a most lucid manner; and the more technical points of the chemical relations of pigments are explained in a way, showing that the authors are thoroughly acquainted with their

subjects. There is an appendix with much valuable information, lists of works for reference, etc., and the volume has a number of handsome illustrations. This treatise must be valuable to any one engaged in painting and decoration, also to a large class of color men, druggists and others, whose business has near relation to this specialty. The volume is literally packed with information, conveyed with a clearness and conciseness which waste not the time of the reader. N.

A PRACTICAL TREATISE ON LIGHTNING PROTECTION; giving complete and explicit Instructions for the Protection of Buildings, and explaining the Defects of Lightning Conductors now Erected. By Henry W. Spang. With illustrations. New and revised edition. New York: D. Van Nostrand, 1883. 8vo, pp. 63.

The present treatise presents in condensed form the general considerations respecting the proper measures to be taken to protect buildings against injury or destruction by lightning which appeared in his earlier treatise on the subject, published in 1877, and which was noticed in the JOURNAL at the time of its appearance. (*Vide* vol. civ, p. 79).

The general views advanced by the author in the present work, are substantially the same as those advanced in his previous work, while the feature of advocating his own particular system and the wholesale condemnation of others is even more pronounced.

It is fortunate for Mr. Spang that his system is in all respects a good one, for this fact serves as a mantle to cover a number of violations of the proprieties in his criticisms of others.

Aside from this fault we may cordially commend the present volume as conveying sound and safe views on the subject it treats of.

Briefly stated, Mr. Spang's system consists in providing an ample number of metallic conductors upon the building to be protected (*i. e.*, an air-terminal conductor upon each of the corners, to protect every portion), connecting these "metallically" with each other, and with a perforated pipe not less than ten feet long, and two inches internal diameter, leading into the earth. This earth connection, which is the distinguishing feature of Mr. Spang's plan of protecting buildings, should be so situated that the waste water from a hydrant or pump, and the roof, "will readily enter it through its top opening, and, passing through its lower and side openings, cause a suitable area of earth around and beneath it to become and remain moist . . . and thereby

effect an easy electrical path between the lower end of the pipe and the subterranean water-bed."

The plan is undoubtedly an excellent one, and in accord with the best practice known to electricians, namely, to employ metallic conductors of ample dimensions upon the building, and to connect these in as perfect a manner as possible with the earth, by carrying their lower terminals down to permanent moisture, or connecting them suitably to a large body of metal.

Mr. Spang, in the course of his work, very plainly exposes certain prevalent errors in connection with the subject of erecting lightning rods, of which it will suffice to mention the inutility of points upon rods, and the folly of insulating the rod from the building. He advocates the connection of the metallic roofs, gutters, leaders, with the ground system, and the employment of gas, water and other inside pipes, as additional protectors, by suitably connecting them with the air-terminals of the rods.

There can be no question that Mr. Spang's plan of protecting buildings, when properly applied, is one of the best that can be devised, in the present state of our knowledge. W.

PRACTICAL CARPENTRY; being a Guide to the Correct Working and Laying Out of all kinds of Carpenters' and Joiners' Work, etc.; to which is prefixed a thorough Treatise on "Carpenters' Geometry." By Fred. T. Hodgson. New York: The Industrial Publication Company, 1883. 12mo, pp. 144, 6 plates.

The title of this work expresses its scope and character very well. It is written by an author who has had some experience in the preparation of workshop manuals for workmen, and who has made a creditable reputation thereby.

The average carpenter, whose time is so fully occupied in the shop that he has little to spare for home study to acquaint himself with many geometrical principles that he nevertheless constantly feels the need of to assist him in laying out his work, and in getting at the readiest, most economical and advantageous methods of performing it, will find Mr. Hodgson's book a useful companion to occupy a corner in his shop or tool-chest, where it may be handy for consultation.

This is the purpose for which the author has prepared the work, as in his preface he desires it to be understood that it "is not intended to take the place of any of the larger and more exhaustive works, but is

designed more particularly for use as a handbook by the workman who has not had time or opportunity to thoroughly commit to memory the principles it contains. . . . There are many whose limited means will not permit of their purchasing a great number of these books, . . . and it is for these men that this manual is prepared."

Briefly summarized, the book is a guide to the correct working and laying out of all kinds of carpenters' and joiners' work, with the aid of a series of illustrated problems, giving the solutions of a great variety of questions that arise in correctly laying out and executing the more troublesome operations that every carpenter is constantly meeting with in his trade. These embrace problems in hip-roofs, Gothic work, centering, splayed work, joints and jointing, hinging, dovetailing, mitering, timber splicing, hopper work, skylights, raking mouldings, circular work, etc., etc. The book contains also a number of useful tables for facilitating calculations, and, in addition to some 150 wood-cuts accompanying the problems, scattered through it with the text, it has six well-engraved plates showing various forms of joints and straps and hinges.

The rules and solutions given throughout the work appear, so far as we have been able to examine them, to be correct, and therefore reliable. Altogether it contains a large amount of useful information, conveyed in an intelligible manner, and it may be safely commended to workmen in carpentry as a serviceable reference book to have at hand. W.

Sand-sharpened Files.—The value of the sand-blast in sharpening files is not limited to the restoration of those that have been worn out, but it is equally evident in the first cutting. Experiments have been tried with bastard files which were finished by the sand blast upon one side, while the other side was simply cut in the ordinary manner; other files of the same size were also tried, which had been worn out and resharpened by the sand-blast. With these files three pieces of gun metal, of equal size and quality, were worked, by making fifty thrusts at a time upon each piece and continuing until one of the files became useless. A similar experiment was tried with cast iron, wrought iron, and steel, showing that the newly finished files were the first to give out and those which were finished with the sand-blast were the most durable of all.—*Dingler's Journal,* April 11, 1883. C.

The Du Puy Process in Spain.—In the year 1878, the proprietors of the *Gaceta Industrial* became satisfied that the Du Puy process, for the direct production of malleable iron from the ore, was a success; but not until the last patent was obtained were they satisfied that it had been brought to such perfection as to be susceptible of no further improvement except in minor details. The requirement of a wrought-iron canister added largely to the expense of manufacture under the first method; that necessity having been now removed, the ore and other ingredients are mixed in a mass with walls of small thickness, without any foreign envelope, and the reduction from the ore to the malleable ball requires only from two to three hours, in furnaces which are badly adapted to the process, and probably less than two hours in suitable furnaces. At first it was thought that a single furnace would not be able to produce more than four or five tons per day, but it is now found that they will yield ten tons or more with the same attendance when in regular operation. The whole process is so automatic that scarcely any supervision is required except in charging and removing the charge. It would be absurd to suppose that this interesting method is to be the only one, or even the prevailing one, in the iron industry; but it is certain that it will always occupy the first rank, and it will form a part of the operations in all large establishments, while it will be the exclusive one in small works. Large manufacturers will absolutely require it, since at the present time they have from 3,000 to 4,000 tons of waste cinder and other refuse, annually turned out from their puddling and heating furnaces and Bessemer converters, which could be made to yield, by the new process, from 40,000 to 50,000 pesetas ($8,000 to $10,000) per annum. In small fabrics the method should make its way exclusively and with certainty, because there is absolutely no way of producing small quantities of malleable iron or Martin-Siemens steel at less cost or with less capital. Moreover, the process may be employed in the production of malleable iron of the best quality, quite equal to that which is made from charcoal pigs, at a cost even less than coke iron. Du Puy's system, therefore, can be applied with visible advantage to all cases in which the Catalan or Tourangin methods are now used and to all cases in which, by utilizing the small and hitherto ruinous furnaces of olden time, the production may be triplicated. The only defect is, that the new process does not economize the ore quite so well as more expensive methods; but that is a slight consideration in Spain, where

the works can be established at the very foot of the mines and where the value of the rich, pure, plentiful and cheap iron ores is only a subordinate consideration. The cost of the slight excess in ore is more than made up by the economy in fuel, the quality of product and the saving in investment. The system seems to be especially adapted to Spain, and the times are quite ripe for its introduction. Repeated trials have been made in Madrid, most of them with a greater or less degree of privacy, but some of them have been of an official character and attended by some of the best Spanish industrial and mining engineers. Señor Don Constantino Saez Montoya was commissioned by the Conservatorio de Artes y Oficios to test the working of the patent; Don Federico Bayo, Don Saturnino Otaegui, Don Luis Barra, Don José Alcover, Don Baldomero Santigos, and Don Juan Gomez Hemas were also in attendance, to represent various syndicates and manufacturers. The operations were conducted under the intelligent direction of Mr. Howard R. Justice, a Philadelphia engineer and son of the proprietor of the European patents. The Rubio ores of Bilbao were employed, assaying 50·29 per cent. From the first operation the proper mixture for reducing the iron was made without difficulty, so as to secure the two aims of commercial success and quick reduction. The charge was reduced in two hours and three-quarters, and was drawn from the furnace in balls as large as the doors would allow; the yield was a ton of hammered blooms for $2\frac{3}{4}$ tons of Rubio ore; at other times a ton of blooms was obtained from $2\frac{5}{16}$ tons of the same ore. It is customary to employ the best coal in such tests, but the operators purposely used Puertollano coal of an inferior quality, in order to demonstrate the double advantages of their method. The iron obtained was of a very satisfactory character, although it was wrought by a very unsuitable hammer. The witnesses of the operation were all of great industrial competency, capable of readily appreciating the fact that the work was performed under unfavorable conditions, and that it nevertheless yielded good results. The moulds were introduced into the furnace while still moist, and they were charged while the furnace was still cool, out of courtesy to the official engineer, in order to occupy as little of his time as possible. The furnace was of the worst type that could be employed for the purpose; direct-firing, with low doors, horizontal grate, very low open ash pit, and cold draught. A proper Du Puy furnace should be gas-heated, with large doors, closed ash pit, and forced draught at low pressure but high temperature. To

obtain a good yield from ores in these unfavorable conditions is a much better evidence of success than to reach ideal results with the best means.—*La Gaceta Industrial*, June 25, 1883. C.

Astro-Photographic Studies.—Since 1874, C. V. Zenger has made photographs of the sun with an astro-photographic apparatus constructed by Browning. He operated with an ethereal solution of chlorophyl, from which he extracted a compound by treating it with sulphuric ether and dried peppermint. He thus obtained a deep green liquid, which could be reduced by the evaporation of the ether to a friable, black, and aromatic substance, which contains ethereal oil of mint. By benzine, pure alcohol, and paraffine, three coloring matters can be separated: green chlorophyl, indigo-blue cyanophyl, and reddish-yellow xanthophyl. Each of these substances has its special absorption-spectrum; when united they absorb nearly all parts of the solar spectrum. In this manner he succeeded in representing the solar corona and the chromosphere, sometimes with a reddish or yellowish color, when the sky was very clear and cloudless. He even obtained the representation of a solar halo, on the 10th of January, 1875, with all the colors visible to the naked eye; these colors remain still unchanged. He obtained a photograph of the solar spectrum, showing the lines from A to H, and even to J and M, when he used his quartz dispersion parallelopiped and quartz oculars or photographic lenses. On March 5th, 1875, he observed, during a heavy wind, some special phenomena to which he has given the name of zones of absorption. The sun's disc was surrounded by sharply defined elliptic zones, showing in the negative with snowy whiteness. Many of the photographs which were taken upon that day showed the phenomenon, which ceased only with the tempest. In repeating the experiment, he finds that these appearances are always manifested before and during heavy gusts; he has also found, during nine years of daily observation, that the phenomena are repeated regularly, at intervals of from ten to thirteen days, and that they indicate the approach of the storm from 12 to 24 hours, even before the barometer or the magnetic needle has shown any signs of disturbance. In examining observation which have been extended over long periods, covering 20 years at stations in Greenwich, Vienna, Prague, and Windsor in Australia, he finds cycles of from 12·7 to 13·1 days in storms and rainfalls. He also finds similar cycles in aurora borealis, solar photographs, American cyclones,

Chinese typhoons, falls of bolides and meteorites, perihelia of comets, and earthquakes. In January, 1883, he communicated to the French Academy some of his results, comparing the dates of the most recent cometary perihelia, the durations of their sidereal revolutions and the duration of a solar half rotation, which led him to the equation

$$\frac{nt}{2} = T,$$

in which n is an integer, t the period of solar rotation, T the duration of the sidereal revolution of the comet or planet. He applies this equation to the eight primary planets and the asteroids Vesta, Juno, Ceres, and Camilla, showing that they all give values for t which have an extreme range of less than one per cent. He considers that the marvelous symmetry which is thus shown furnishes a striking example of the simplicity and perfect symmetry of the solar system, and that we can consider the same law of periodicity as governing the movements of planets, comets, meteoric displays, planetary atmospheres, aurora borealis, changes of electric and magnetic condition, and seismic movements. It therefore seems to him very probable that the sun acts as an enormous dynamo-electric machine connected with others, their mutual energy being manifested in determining all the movements in inter-planetary space and on the surface and in the interior of the planets themselves, and that their revolutions, like those of comets and meteorites, are only the movements resulting from the actions of the dynamic poles of this enormous source of energy.—*Comptes Rendus*, August 27, 1883.

[Zenger makes no attempt to explain his harmonies, but they may be simply accounted for on a principle which is given in Rankine's "Manual of Applied Mechanics," p. 576: "in a rotating vortex, the dynamic head, at any point, is the height due to the velocity, and the energy of any particle is one-half actual and one-half potential." Chase has applied this principle (*Proc. Amer. Phil. Soc.*, vols. ix–xxi) to an explanation of the dependence of all the motions in the solar system on the wave velocity of light. The hypotheses of Siemens and Duponchel, respecting the conservation of solar energy, may, perhaps, be more fully and satisfactorily elucidated by the same principle.] C.

Telluric Spectral Bands.—Admiral Mouchez has presented to the French Academy a note of M. Egoroff, upon the production of the fundamental telluric bands, *A* and *B*, of the solar spectrum, by

an absorbing layer of oxygen. Angström observed the disappearance of the group *a* during heavy frosts, while *A* and *B* remained. We may, therefore, suppose that *A* and *B* are solar groups, or inter-planetary groups, or telluric groups which are due to other atmospheric elements than the vapor of water. The successive experiments made at the Paris Observatory, upon the successive absorption of atmospheric layers of different thicknesses, between the limits of 10,000 metres and 80 metres, have shown that *A* and *B* are telluric groups, and that *A* is the more fundamental of the two. Direct observations upon the absorption spectra of carbonic acid, ammonia, and ozone, taken in layers which correspond to atmospheric layers of more than 100 kilometres in thickness, have shown that those gases have nothing to do with the groups in question. Egoroff placed in the physical laboratory of St. Petersburg a tube, 20 metres long and 50 millimetres in diameter, in which the air or its constituent gases could be subjected to a pressure of 15 atmospheres. A Drummond light was concentrated, after passing through the tube, upon the slit of a large Merz spectroscope, by means of an achromatic lens having the same focal distance as the collimator. Air compressed with five atmospheres gives *A* plainly visible; under a pressure of eight atmospheres it becomes deeper, broader, and more distinctly marked. On adding oxygen to the air in the tube and maintaining the pressure of the mixture at seven atmospheres, *A* becomes very distinct, under the form of a double group, of which the more refrangible portion is darker than the other. Each group appears to be composed of a multitude of fine lines. Oxygen pure and dry shows *A* under the pressure of a single atmosphere. With a pressure of three atmospheres, it becomes plainly double. At a pressure of six atmospheres, it is largely developed and the group *B* is added. At eight atmospheres, the two groups are strengthened and enlarged. They are, therefore, due to the oxygen of the air. Hydrogen, under a pressure of three atmospheres, shows no trace of line or band in the visible portion of the spectrum. The same thing is true of ordinary illuminating gas, and of air saturated with benzine, which controverts the opinion of M. Abney that the groups are attributable to absorption by hydrocarbons in inter-planetary space.—*Comptes Rendus*, Aug. 27, 1883. C.

Dwarfs and Giants.—M. Delbeuf, in a late address to the Royal Academy of Belgium, skillfully attacks some of the common notions

in regard to the relative degrees of force which are exerted by different forms of animal life. We are astonished when we first hear that a flea can jump 200 times his own length. Our admiration is changed into stupefaction when a simple calculation shows that if nature had endowed the horse with a like power, but increased in proportion to its weight, it would be able, at a single bound, to leap over the Rocky Mountains. If man had a velocity proportioned to that of certain insects, he would traverse more than ten leagues in a minute, which is 60 times the speed of an express train. The Amazon ants, in starting on a warlike expedition, travel about two and a half yards per minute. The celebrated heroines of antiquity who gave their name to these turbulent insects, would have traveled on foot eight leagues per hour, if their speed was proportioned to their size. We ought, however, to compare the forces which move given masses, and to consider the relative weights or volumes. Under this view, the warlike inhabitants of the banks of the Thermodon should have traveled 150,000 miles per hour. That is enough to frighten the boldest imagination. And yet who will deny the truth of the observations, the accuracy of the measurements, and the justice of the reasoning. In all such comparisons there is a scientific delusion which may be easily dissipated. The proper subject of consideration is the work necessary to raise a certain weight. The work increases in joint proportionality to the weight and height. When two animals, of different masses, leap to the same absolute height, each one accomplishes an amount of work which is precisely proportional to its mass. When a man jumps over an obstacle which is two feet high, he accomplishes a work which is twice as great as that of the flea or the grasshopper, which can scarcely jump a foot. These views are illustrated by interesting comparisons between the inhabitants of Lilliput and Brobdingnag, by the rapidity of motion in the wings of insects, and in various other ways.—*Rev. Scientif.*, Jan. 27, 1883. C.

Material Particles in Electric Sparks.—Friedrich Wächter publishes the following conclusions from his experiments: 1. There is a removal of particles from the anode, in atmospheric air, under pressures varying between 4500 and 10 millimeters of quicksilver; the removal of particles from the kathode is observed only under pressures between 63 and ·005 mm. 2. The quantity of particles removed in equal times and under similar circumstances, diminishes at the anode

and increases at the kathode with diminishing pressure. 3. The anode particles are carried to a much greater distance than the kathode particles, under the same circumstances (at 63 mm. pressure about 3400 times as far). 4. The anode particles proceed, under all pressures, from a comparatively small surface; the kathode particles are thrown from surfaces which increase with diminishing pressure and are sometimes 10,000 times as great as that of the anode particles. 5. The anode particles always proceed from the portion which lies nearest to the kathode; the kathode particles may go from its entire surface. 6. The projection of anode particles is aided by a curved or pointed form of the electrode; that of the kathode particles by a clean unoxidized surface. 7. The anode particles proceed to the kathode in the direction of least resistance. The movement of the kathode particles is normal to the surface and uninfluenced by the place of the anode or the direction of the current. 8. The anode particles may move in all imaginable curves; the direction of the kathode particles is rectilinear. 9. The anode particles are deflected by a magnet as if they were diamagnetic; the kathode particles as if they were paramagnetic. 10. The anode particles are transported both in luminous and in non-luminous conditions; the kathode particles only when non-luminous. 11. The anode particles have a measurable magnitude and are apparently torn off mechanically; the kathode particles are inappreciably small and appear to be produced by a kind of evaporation. 12. The heating of the electrodes favors the projection of particles from the kathode; the influence upon the anode is somewhat doubtful. 13. The kathode particles facilitate the passage of the electric current from the electrode to the gas molecules; this is not the case with the anode particles. 14. The researches of G. Wiedemann and Kuhlmann show that a greater electric tension is requisite for the projection of particles from the anode than from the kathode. These facts are supposed to show a difference between positive and negative electricity, which is qualitative, and which cannot be explained by the mere excess or deficiency of a single activity.—*Ann. der Phys. u. Chem.*, Nov., 1882. C.

Powdered Asbestos.—M. Erichsen, of Copenhagen, uses powdered asbestos for making a special enamel or coating. The powder is mixed with soluble salts, such as silicate of potash, and mineral or other colors which combine with the silicic acid, so as to form a product which resists the action of oxygen, heat, cold and moisture. This furnishes a refractory glazing, which protects porous materials and

which can be applied to wood, to gas or water pipes, to brick walls, to constructions of stone or cement, etc., etc. It has been proposed to use it in boilers, to protect the plates against the too great intensity of the fire. When applied to masonry or to wooden objects, the surface is first washed with water and soap. In the preparation of the coating it is only necessary to use the refuse of the asbestos, which would be worthless for any other purpose.—*Chron. Industr.*, Jan. 21, 1883.

Utilizing Subterranean Heat.—Many methods have been proposed for utilizing the internal heat of the earth, and if we remember that the temperature increases at an average rate of about 1° F. for each 50 feet of increasing depth, it will be readily seen that such utilization is quite possible. It is probable, however, that the excavation of wells, deep enough to boil water and produce steam, would involve a greater cost than the production of steam by the combustion of coal or by solar heat. The Japanese are seriously considering the utilization of the hot springs near Tokio, as a means of producing heat and power. The subject has been discussed in the Japanese Seismologic Society. In a country where the presence of hot springs and the frequency of earthquakes indicate a rapid increase of subterranean temperature, the thing may be quite practicable. It has even been questioned whether the extraction of the heat would not diminish in some degree the frequency and intensity of earthquakes.—*Soc. des Ing. Civ.*, Oct., 1882. C.

Electric Shadows.—P. Riess has published the following laws: An electrized surface shines in the open air, only in the places which have been struck by an oppositely electrified air current. The surface does not shine where the current is interrupted by an interposed conducting body, but there is a shadow of the same form as the interposed body. If the current is not discharged, but only turned aside by a non-conductor, there is usually no shadow; but in feeble machines a small conductor sometimes produces a slight shadow.—*Ann. der Phys. u. Chem.*, Nov., 1882. C.

Electrical Wood Cutting Machine.—Th. Günther, of Zerbst, has patented a wood cutting machine, in which a number of platinum wires are united in a frame and heated by a galvanic battery, so as to be used as saws for cutting logs into boards.—*Dingler's Journal*, December 6, 1882. C.

Homeopathy and Radiant Matter.—The homeopaths claim that medicinal matter when reduced to infinitesimal proportions has

special and powerful efficacy; their adversaries ridicule the idea. The experiments of Crookes have shown that radiant matter possesses new properties. An enthusiastic admirer of Hahnemann cites this fact as a strong confirmation of the infinitesimal theory.—*Les Mondes*, April 14, 1883. C.

OBITUARY.—JOHN C. TRAUTWINE.

John Cresson Trautwine, the eminent civil engineer, whose death occurred on the fourteenth of September, 1883, at his home in Philadelphia, was the eldest child of the late William Trautwine, Sr., and Sarah Wilkinson, his wife. He was born in this city March 30th, 1810, and his early childhood was passed at his father's house on Water street, near Market, adjoining that of the late Stephen Girard.

While very young he acquired a marked fondness for the natural sciences, particularly physics and mineralogy. In all probability this inclination was awakened by his father's friends, one of whom, the late Joseph Loughead, Sr., at that time a prominent teacher, took much interest in the boy and encouraged him in various ways. When about seven years old, he one day strolled away from the house and was so long absent that his father began a search for him which ended by his discovery, fast asleep, on a stall in the old Market street market sheds, with his pockets so stuffed with mineral specimens from the adjacent country that he could walk but with difficulty. Soon after this he was placed under the charge of the late James P. Espy, who may be said to have been the father of the system of organized meteorological observations and under whom he studied natural philosophy and mathematics. At an early age he learned to draw and paint with facility and quickly became an adept in water coloring. His rough note-book contains exquisitely painted little sketches of bridges, parts of buildings and other subjects, on the margin of pages crowded with hastily written memoranda.

In 1828, when eighteen years old, he entered the office of the late William Strickland, at that time located on the south side of Arch street, above Sixth, opposite the theatre then being built. Mr. Strickland was the most promiment civil engineer and architect in this part of the United States and young Trautwine, while with him, was engaged on some of the principal engineering works of that day.

Soon after entering Mr. Strickland's office, in 1828, he prepared and submitted a competitive design for the Penn Township Bank, opposite

Franklin Square, at Sixth and Vine streets. His design was accepted and he superintended the erection of the building. He also designed and supervised the placing of the iron-railing around Franklin Square, now in process of removal.

With two of his fellow-students in Mr. Strickland's office he formed an intimacy which continued for years. One was Ellwood Morris, the well-known engineer, with whom in later years, he shared an office in the Franklin Institute building, and the other was Thomas U. Walter, who subsequently became architect of Girard College and of the new Capitol building at Washington.

The Delaware Breakwater was constructed under Mr. Strickland's supervision and Mr Trautwine was for some time engaged on that work. He also assisted Mr. Strickland in the erection of the United States Mint, the Blockley Almshouse and many other prominent buildings.

While in Mr. Strickland's office, it was his duty to exhibit and explain to callers a model railroad section, adapted to cars with flanged wheels. The young and enthusiastic visitors foresaw a practical use for this arrangement, but the older and more conservative detected its visionary character. Here was the beginning—the birth of railroad engineering in America; and it was the destiny of the subject of this memoir to foster its development, by the field-labor of his earlier manhood, and in later life, by his published engineering-works, which may be found in the hands of almost every engineer in the United States.

In 1831 he was engaged on the Philadelphia section of the Columbia Railroad, from the old Columbia, or Peter's Island, Bridge, over the Schuylkill river (a detailed description of which he published in the FRANKLIN INSTITUTE JOURNAL for August, 1834), to Broad street, and in 1832 he laid out Logan Square. He competed successfully for the design of the Moyamensing Commissioners' Hall in 1833, and in the same year, together with the late J. Edgar Thompson, afterwards president of the Pennsylvania Railroad, made a survey for a canal from Fairmount to the mouth of Mill creek, near Gray's Ferry.

In 1835 he was appointed principal assistant engineer on the Philadelphia, Wilmington and Baltimore Railroad. At Havre de Grace, in this year, he became acquainted with the late Benjamin H. Latrobe, of Baltimore, subsequently engineer of the Baltimore and Ohio Railroad, with whom he formed a lasting friendship, and to

whom he long afterwards dedicated his principal work on engineering. In 1836 he was appointed engineer of the Philadelphia and Trenton Railroad, on the resignation of Mr. Samuel Kneass; but resigned on receiving, in the same year, the appointment as chief engineer of the Hiwassee Railroad, extending from Tennessee into Georgia. Having married in 1838, Miss Eliza Ritter, daughter of the late Mr. Jacob Ritter, Jr., of Philadelphia, he built a residence in Knoxville, Tennessee, expecting to continue there as permanent engineer of the road after its completion. The various State governments were at that time undertaking extensive measures to open up and develop the wilder sections, and Mr. Trautwine wrote and published an extended article upon the Internal Improvement of the South. The financial disturbances of the period involved the Hiwassee Railroad, which suspended work at the time when the chief engineer, with the president, General Jacobs, were on the eve of constructing rolling-mills to manufacture for the road the first iron rails to be made in this country. Mr. Trautwine left Tennessee and returned to Philadelphia in 1843, having been engaged on the Hiwassee Railroad nearly six years. He next surveyed the route for the Ralston and Blossburg Railroad, in Pennsylvania, and soon after, in 1844, sailed for Carthagena, New Granada, S. A., where, for five years, he was engaged with General George M. Totten in the construction of the Canal del Dique, connecting the Magdalena river with the bay of Carthagena. His extended work here, surmounting all the natural obstacles which a vast tropical swamp could oppose to man's skill and labor, was a fitting preparation for that after-work, with which his name will ever be associated, on the Isthmus of Darien and the Atrato. Returning to the United States in 1849, he surveyed the borough of Germantown, now the Twenty-second Ward of Philadelphia, correcting errors of long standing, and rearranging the lines of many streets, to which he gave their present names. Before the expiration of that year, having been appointed, jointly with General Totten, engineer of the Panama Railroad, he left Philadelphia for the Isthmus of Panama in December, and in January, 1850, began the surveys which finally determined the route of that highway of nations. A writer in *Harper's Monthly Magazine*, for January, 1859, says of this undertaking: "Well might the hardiest projectors have shrunk from attempting its construction. The first thirteen miles, beginning at Navy Bay, were through a deep morass, covered with the densest jungle, reeking with malaria, and

abounding with almost every species of wild beasts, noxious reptiles and venomous insects known in the tropics. * * * Further on, the line was through a rugged country, along steep hill-sides, over wild chasms, spanning turbulent rivers and mountain torrents, until the summit ridge was surmounted, when it descended abruptly to the shores of the Pacific Ocean. Mr. Trautwine, after a careful survey of the whole line of Atlantic coast from the mouth of the Chagres to the harbor of Portabello, located the eastern terminus at the island of Manzanilla, on the bay of Limon, or Navy Bay, where the City of Aspinwall now stands, and with Mr. J. L. Baldwin as assistant, began from this point, one of the boldest engineering enterprises ever attempted."

He prepared a map of the Isthmus, a reduced copy of which will be found with a description, in the FRANKLIN INSTITUTE JOURNAL for January, 1871.

Returning from Panama to Philadelphia in 1851, he published, in the same year, the first edition of his "Curves" and "Excavations and Embankments," and in April, 1852, again sailed for the Isthmus of Darien, to seek an inter-oceanic canal route *via* the Atrato river. This stream flows northward through New Granada into the Gulf of Darien, along the base of the western Andes. Humboldt, long before, basing his conclusions on superficial observations and tales of the natives, had hinted at a possible canal route through a hoped-for depression in the mountain chain, by which a short water communication would connect the Atrato river and Pacific Ocean. Mr. Trautwine, having surveyed the Gulf of Darien and the several mouths of the Atrato, ascended that river to its source, diverging to examine its principal tributaries. Crossing the dividing ridge between the Atrato and San Juan, he descended the latter river to the Pacific Ocean, finding the fabled Canal of Raspadura, long believed to exist between the head waters of the two rivers, and through which canoes were said to pass from ocean to ocean, *a hill*, up and down which canoes were dragged in their passage. Having examined the Pacific coast-line bordering the western Andes, he crossed the range at various points, ultimately deciding upon a canal route from the Atrato, at Vigia Curbarador, to Cupica Bay on the Pacific, as the least inadvisable. The cost he estimated at $325,000,000. A detailed report of this survey was published in the FRANKLIN INSTITUTE JOURNAL for 1854, and afterwards in book form, with lithographic illustrations and maps by the author. As a

summary he says, in this report: "I have coasted and boated along both sides of the region comprised between the Pacific Ocean (from Panama to Buena Ventura), on one side, and the Caribbean Sea, the Atrato, and the San Juan on the other side; and have crossed it both at the site of the Panama Railroad and at three other points more to the south. From all I could see, combined with all I have read on the subject, *I cannot entertain the slightest hope that a ship-canal will ever be found practicable across any part of it.* When I employ the word *practicable* it is meant in a practical sense."

Of this survey, Admiral Davis, in his Report on Interoceanic Canals and Railroads, made in 1867, to the Secretary of the Navy, states that subsequent explorations have confirmed both the details and general results.

Mr. Trautwine next examined and reported upon the harbor of Arecibo, in Porto Rico, after which, and until 1855, he acted as engineer of the Coal Run Railroad, in northeastern Pennsylvania. His right arm was crushed between two iron coal-cars, of new design, which he was examining at Port Richmond, when the accident occurred. The loss of his arm, however, did not materially interfere with his surveys, literary work, or even his designing and art-work. Claiming that power resided in the mind rather than in the member, and that the will and intelligence of the former should soon teach an unaccustomed intrument to excute its purposes, he demonstrated, by his after-work, the correctness of his view.

In 1856 he surveyed the Lackawanna and Lanesboro Railroad in northeastern Pennsylvania. In 1857 he again left the United States for Honduras, where he surveyed the route for an inter-oceanic railway, passing through Comayagua, the capital. This survey was completed the following year. War in the United States, a year later, interfered with the further progess of this enterprise, which some time afterward interested the late Emperor Napoleon III, but was never executed.

In 1858, by invitation of Sir John A. Macdonald, Premier of Canada, he examined and reported upon the harbor of Montreal, with a view to its increased adaptability as a port of entry, arranging a new system of docks for that city. In 1864 he planned a harbor for Big Glacé Bay, Nova Scotia, and soon afterwards reported upon a system of water-supply for Rochester, New York.

After this time he occasionally acted as consulting engineer, or

testified as an expert, when engineering questions were involved, but otherwise retired from the active duties of his profession, devoting himself to study, the investigation of abstract engineering problems, and the constant revision of his published works. In 1871 the first edition of the "Engineers' Pocket Book" appeared. This work, which was the product of a life coeval with the development of modern engineering science, immediately received the favor of the profession; more than twenty thousand copies having been issued since that date. Several years since, he associated with himself, in the work of revising his publications, his son, John C. Trautwine, Jr., and within the past year practically yielded to him the task which was manifestly growing too great to continue. His health had been growing worse for a long time, and since the spring of 1883 he suffered from extreme and gradually increasing prostration, superinduced, without doubt, by excessive exposure in his earlier life. He continued at work, however, until within two weeks from the time of his death, growing weaker from day to day, but striving, to the last, to effect by will and ingenuity, the loss of physical vitality. During the night, two days before he died, he asked, toward morning, "What time is it?" His son told him the hour, and he replied, "The steamer—the steamer from Aspinwall—our passage—from New York." A few moments later he exclaimed, "Honduras—Europe—Europe!" his mind in these last hours, mechanically retracing the eventful periods thirty years past. He died quietly, and apparently without pain. His widow survives him, with two sons, William Trautwine, conveyancer, and John C. Trautwine, Jr., civil engineer; his only daughter, Mrs. Susan R. MacManus, having died two years previously.

Mr. Trautwine was a member of the Franklin Institute, the Academy of Natural Sciences, the American Philosophical Society, the Historical Society and other learned bodies, and frequently contributed to their publications, and to other journals, articles on technical and scientific subjects.

As a mineralogist he was widely known, and enjoyed the friendship of Dana, Brush, Rand, Roepper and others eminent in this science. His collection of mineral specimens was one of the most unique in this country.

Whether, in future years, his reputation will rest mainly on his explorations or his writings, cannot now be determined. Through each, he attained a world-wide celebrity. He was the first man to

supply both accurate and comprehensive knowledge of the Isthmus of Darien. All subsequent explorers refer to his work, confirming its results; and it is probable that, a century hence, his name will be as closely identified with schemes of inter-oceanic communication as it is to-day. His published writings, on the other hand, are the text-books of the engineering profession; his name being related to it as that of Gray to botany, or Dana to mineralogy; and, under the editorial care of his son, who was favored with his special instruction, the present standard of his "Pocket Book," and other works, will doubtless be maintained.

At the close of this review of a varied and pre-eminently useful life, it will suffice to say that, at the time of his death, which occurred at the age of seventy-three years, Mr. Trautwine stood in the foremost rank of his profession.

THO. U. WALTER,
JOS. M. WILSON,
FRED. GRAFF.

Franklin Institute.

[*Proceedings of the Stated Meeting, held October* 17, 1883.]

HALL OF THE INSTITUTE, Oct. 17, 1883.

The meeting was called to order at the usual hour, with the President, Wm. P. Tatham, in the chair. There were present 71 members and 17 visitors.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at the stated meeting of the Board, held Wednesday, October 10th, 6 persons had been elected to membership. He also reported the minutes of the several standing committees. There were no reports of special committees, and no papers announced.

The Secretary's report embraced some remarks on Professor S. P. Thompson's recent work, advocating the claims of Johann Phillipp Reis, to be recognized as the first discoverer of the electric transmission of speech, and the inventor of devices and instruments corresponding in their construction and objects with those now used in what is known as the Bell system of telephony; a description of the electrical railway

system of Mr. Leo Daft; and an abstract of the impending changes in the British Patent Law.

A specimen of the "Compound Wire" of the Postal Telegraph Company of New York was shown and described. It consists of a steel wire core weighing 200 pounds to the mile and having a tensile strength of 1650 pounds, on which copper is deposited by the electro-plating process to any desired thickness. At the present time, the factory at Ansonia, Conn., has in use for the purpose, twenty-five large dynamo machines, depositing about 10,000 pounds of copper per day. The copper is deposited uniformly over the whole surface of the steel wire, the latter being passed slowly and continuously through the depositing solution, the time required from its entrance to its emergence as finished "compound wire" being 60 hours, in which time a copper deposit is obtained equivalent in weight to 500 pounds per mile. On the present scale of working about 50 miles of the wire are in the solution at all times. The compound wire is claimed to have a number of advantages over the iron wire now in use for telegraphic purposes, of which the more noteworthy are—much greater conductivity, greater tensile strength, greater durability, cheapness as to first cost and maintenance as compared with iron wire of the same conductivity, and low resistance, enabling fewer cells of battery and currents of very low tension to be used, and insuring uninterrupted communication in all kinds of weather.

An improved gasoline lamp for the use of plumbers and others requiring a portable flame for melting, soldering, and kindred work, was also shown on behalf of Mr. Ingram, of Philadelphia.

Dr. I. Kitsee, of Cincinnati, was then invited to describe his Automatic system for the Detection of Fire-damp in Coal Mines by electrical means.

Dr. Kitsee made some introductory remarks bearing on the importance of some reliable automatic means of detecting the presence of explosive gases in mines, to prevent the frequent recurrence of explosions and calamitous loss of life, and then proceeded to describe his system, as follows:

"The working of this detector or indicator is very simple. A metallic box of which two sides are covered with fine wire gauze is enclosed in another metallic box somewhat larger, with the same wire gauze on the same sides. A clockwork is placed between the walls of these two boxes. A fine silken thread attached to the clock-spring is

drawn across the inner box and fastened on the opposite wall of the same, holding the whole clockwork in check. The same clockwork has also a wheel with spurs arranged in such a way that the striking of the same on a small metallic plate connected with a wire leading from a battery, will close a broken circuit, as the wheel itself is connected with the other wire of the same battery. A common electric bell will then at each striking, sound the alarm. The spurs or points of this wheel are in each apparatus differently arranged to strike different numbers, just as in the common fire alarm apparatus. The platinum ends of two needles connected with another battery, are placed in the centre of the same box in juxtaposition to each other. If now an electric current is sent through the last circuit wires, strong enough to produce a spark between the two platinum points and at the same time there happens to be an explosive mixture of the fire-damp in the box, so that an explosion occurs and the silken thread is burned in consequence, the clockwork is set in motion and by making and breaking the other circuit indicates the place from whence the alarm comes.

"As to the placing of the apparatus I would only say that the box or boxes, as the case may be, shall be placed in different parts of the mine, at intervals of 300 feet in each gallery, securely fastened to the roof; to the roof for this reason, because, as is well known, the gas being lighter than air, may already have accumulated in dangerous quantities in the upper parts before any appreciable quantity can be found on the lower levels.

"The wires leading to and from the boxes are placed in a leaden tube or pipe, not only to prevent accidents to, but also from the same.

"The alarm-bell and batteries, as also the indicating board, are placed in the office of the superintendent. Every morning before the miners descend to their work, the superintendent sends an electric current through the above-described wires; if now, as an answer, the alarm apparatus sounds, he will know that an explosion has occurred in one of the boxes, and at the same time know in which box and in what part of what gallery. He will not allow the men to resume work ere that part of the gallery has been purified by means of the air-pump or by the other methods well known to miners. Should no answer follow, he may rest assured that his laborers will be as safe in the coal mine as in the best ventilated work-shop."

An exhibition of the working of the apparatus was given at the close of the speaker's remarks.

Some remarks were presented by Mr. Wm. J. Gregory, of Philadelphia, on the subject of subways in cities, which he illustrated by means of lantern projections of a number of views of notable structures of this kind in European cities, especially in London. Mr. Gregory clearly set forth the growing necessity of such subways in all large cities, in view of the multiplication of underground pipes for various forms of service (sewerage, gas and water distribution, steam heating, electric conduits, etc.), and in view of the inconvenience and obstruction to traffic resulting from the frequent tearing up of streets for the laying of new lines or the repair of old ones.

Under the head of Deferred Business, the report of the "Joint Committee on the Reading of Papers" was called up for disposition. After some discussion, final action thereon was postponed until the November meeting, and it was made the special business of that meeting.

Under New Business, Mr. J. W. Nystrom offered the following preamble and resolution, viz.:

To the President and Members of the Franklin Institute.

WHEREAS, The City of Philadelphia has suffered a great many disastrous steam boiler explosions which could have been prevented by proper precautions, and

WHEREAS, There are now in use in the City of Philadelphia some six hundred boilers which have dangerous flat cast iron heads, and that either one of them is liable to explode at any moment if in charge of incompetent attendants, and

WHEREAS, Such a great number of dangerous steam boilers cannot reasonably be removed without great inconvenience and expense to the owners of these boilers, and

WHEREAS, It is known that the explosions of this class of boilers have been caused by incompetent attendants, be it

Resolved, That the Mayor and Select and Common Councils of the City of Philadelphia be respectfully requested by the Franklin Institute to pass an Ordinance to the following effect, viz.:

Supplement to an Ordinance of July 13, 1868, *entitled an Ordinance regulating the Inspection of Steam Boilers in and for the City of Philadelphia, Pennsylvania.*

SECTION 1. *The Select and Common Councils of the City of Philadelphia do ordain*, That from and after the 1st day of January, 1884, all engines and steam boilers operated in the City of Philadelphia shall be run and in charge of only such engineers as shall be furnished with a proper certificate as hereinafter provided.